How do Sociomaterial Networks Involving Large-Scale Automation, Come into Being, Persist and Change Over Time, Within a Healthcare Environment?

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Abstract

The aim of this thesis is to develop a theoretical model to explore how sociomaterial networks, involving large-scale automation, come into being, persist and change over time, within a healthcare environment. It does so by bridging the gap between design, implementation and use of large-scale pathology automation (LSPA) within two United Kingdom (UK) National Health Service (NHS) laboratories. A longitudinal, multi-site, ethnographic approach was used, along with semi-structured interviews, template analysis and participant observation of LSPA 'in-practice'.

This research has suggested that design features, embedded within the material properties of LSPA, were purposefully intended to bring about organisational change. In both user organisations, the material affordances of LSPA resulted in anticipated skill mix changes. However, material constraints required the enforcement of changes to organisational routines, creating operational difficulties, which were then subsequently transferred across organisational boundaries by the researcher/manager. The identification of these sociomaterial affordances and constraints, in conjunction with humans acting as boundary objects, had the unintended consequence of influencing strategic decision making and initiating structural and cultural change.

The development and practical application of the resulting SociomANTerial model allowed the researcher to trace the analytical history of these organisational changes over time and consider the impact of broader social structures such as power. Ultimately it is suggested that a greater emphasis on collaboration between users, designers and corporate agents will result in more innovative approaches for technology adoption and improved organisational design.

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Accident & Emergency	A&E
Actor Network Theory	ANT
Alcoholic Liver Disease	ALD
Chief Executive Officer	CEO
Commitment Accounting	CA
Computer Aided Software Engineering	CASE
Computer Physician Order Entry	COPE
Computerised Tomography	CT
Clinical Pathology Accreditation	CPA
Deoxyribonucleic Acid	DNA
District General Hospital	DGH
Electronic Patient Record	EPR
Enterprise Systems	ES
Foundation Trust	FT
Full Business Case	FBC
General Practitioners	GP
Health Care Solutions	HCS
Hospital Information System	HIS
Intensive Care Unit	ICU
Information Systems	IS
Information Technology	IT
Just-in-Time	JIT
Large-scale Pathology Automation	LSPA
Laboratory Information System	LIMS
Lean Manufacturing and Resourcing	LMR®
Managed Service Plan	MSP
Master of Business	MBA
National Health Service	NHS
National Programme for IT	NpfIT
National Vocational Qualification	NVQ
North East Pathology modernisation	N.E.Path
North East Transformation System	NETS
Obligatory Passage Point	OPP
Order Communications	Order Comm
Outline Business Case	OBC
Payment by Results	PBR
Picture Archiving and Communication Systems	PACS
Public Funding Initiative	PFI
Quality Control	QC
Quality, Innovation, Productivity and Prevention	QIPP
Social Construction of Technology	SCOT
Statim (immediately)	STAT
Strategic Outline Case	SOC
Sociotechnical Systems	STS
Time 1	T1
Time 2	T2
Time 3	T3
Time 4	T4
Time Phased Budgeting	TPB
Toyota Production System	TPS
United Kingdom	UK
United States of America	USA
Value Added Tax	VAT

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Declaration

I declare that the work contained in this thesis has not been submitted for any other award and that it is all my own work. I also confirm that this work fully acknowledges opinions, ideas and contributions from the work of others.

Any ethical clearance for the research presented in this thesis has been approved. Approval has been sought and granted by the University Ethics Committee (Appendix 1). After due consideration NHS ethical approval was not considered to be required under NHS research governance arrangements (Appendix 2).

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Chapter 1 Introduction

1.0 Introduction

The aim of this thesis is to develop a theoretical model to explore how sociomaterial networks involving large-scale automation, come into being, persist and change over time, within a healthcare environment. This chapter highlights the rationale behind this research, the methodological approach and a summary of the main results. Finally the organisation of the thesis is described and summaries of the chapters are provided.

1.1 Rationale for this research

The role of technology on organisations has developed extensively over the past years reflecting the philosophical opposition between the 'subjective and objective realms of social science' (Orlikowski, 1992, p. 399). Technological determinism for example takes an objective stance and is based on the assumption that 'technology as well as the individual and organisational variables can be measured and predicted' (Orlikowski, 1992, p.400). In doing so technology is considered to 'exert a unidirectional causal influence over humans and organisations akin to those operating in nature' (Giddens, 1984, p. 207). Indeed early contingency theorists (Woodward, 1958, 1965; Galbraith, 1977) considered technology to be a 'production system' whereby technology was considered to be an 'independent variable', and the arrangements among people for getting work done a 'dependent variable' (Perrow, 1967, p.195). Within a healthcare environment it is argued that technological determinism is the dominant paradigm. What began as the introduction of 'simple tools' has become almost 'autonomous elements of today's bioscience' (Wolf and Bishop-Berele, 1980, p.125).

Within a UK pathology laboratory technological determinism manifests itself as an on-going desire to adopt and utilise new technologies, including the introduction of fully automated LSPA systems. The LSPA technology aims to automate almost the entire pre-analytical pathology process, including specimen handling and automated specimen delivery via an integrated single tracking system. In essence the pathology process is transformed into a manufacturing style production line.

A number of researchers however have highlighted grave concerns over the dominance of technological determinism, in that it largely ignores the influence of human agency or free will in 'developing, appropriating and changing technology' (Orlikowski, 1992, p. 400; Mumford, 2006), whilst at the same time overlooking the way 'social systems shaped technologies and their use' (Leonardi and Barley, 2010, p. 4).

Alternatively a later group of researchers focused on the subjective social aspects of technology exemplified by the sociotechnical studies. The sociotechnical systems (STS) model is premised on the belief that outcomes such as 'job satisfaction' and 'productivity of workers' can be manipulated by 'jointly optimising the social and technical factors of a job' (Trist and Bamforth, 1951; Trist et. al., 1963).

Drawing on his experience with the development of an electronic patient record (EPR) on an Intensive Care Unit (ICU), Berg (1999, p.88) states that 'socio-technical approaches put people and their working relationships centre stage and form a long-needed antidote to technology centred, top-down approaches'. In recent times the focus of STS has then moved away from the 'direct focus of ‘workers emancipation’ and now embraces a ‘user orientated perspective’ (Berg, 1999, p.88).

According to Orlikowski (1992, p.401) sociotechnical studies rely too much on the ‘capabilities of human agents’. As a result the appropriation and deployment of a technology depends on ‘social and economic forces beyond managerial intent’, which may ‘thwart any intended reconstruction of jobs and technology’. Some of these forces include ‘institutional properties of the organisation, micro politics of the workplace, features of the environment, and unintended consequences of organisational change’ (Orlikowski, 1992, p. 401).

Another criticism of technological determinism and STS is that according to Orlikowski (2010, p.134) both approaches are based on ‘ontology of separateness’, which claims that ‘agency is located in either the human or in the artefact’.

Recently this ontological perspective has been challenged by a group of researchers (Pickering, 1995; Knorr-Cetina, 1997; Barad, 2003; Latour, 2005; Suchman, 2007) who have been working with a ‘relational ontology’ that ‘rejects the notion that the world is composed of individuals with separately attributable properties’ (Orlikowski, 2010, p.134). Thus the social and the technical are posited to be ‘ontologically inseparable’ (Orlikowski, 2010, p.134). This relational ontology or ‘entanglement in practice’ (Orlikowski, 2010, p.135) is beginning to influence research on technology in the management literature for example ‘actor networks’ (Callon, 1986; Latour, 1992, 2005), ‘sociotechnical ensemble’ (Bijker, 1995), ‘mangle of practice’ (Pickering, 1995), ‘object centred sociality’ (Knorr-Cetina, 1997), ‘relational materiality’ (Law, 2004), ‘material sociology’ (Beunza, et.al. 2006) and ‘multi-dimensional networks’ (Contractor, Monge and Leonardi, 2011). A shift can therefore be seen in the conventional framing of organisational practices from social, to 'sociomaterial' (Mol, 2002; Suchman, 2007).

Within this context the social and the material are postulated as being inextricably linked or 'constitutively entangled' in everyday life (Orlikowski, 2007, p. 1437). In doing so the concept of sociomateriality presumes that there are no independently existing entities with inherent characteristics. Humans are thus 'constituted through relations of materiality, bodies, cloths, food, devices, tools, which in turn are produced through human practice' (Orlikowski, 2007, p. 1438). There is 'no social that is not material and no material that is not social' (Orlikowski, 2007, p. 1437).

With reference to other relational ontologies such as Actor Network Theory (ANT), the sociomaterial perspective shifts the epistemological and methodological orientation away from 'tracing ties in networks towards an examination of performativity and reconfiguration' (Orlikowski and Scott, 2008a, p.25). The transition from 'interaction', which presumes a prior existence to 'intra-action', is thus considered to constitute a 'profound conceptual shift' (Barad, 2003, p.815).

More recently however the concept of sociomateriality, based on the 'agential realist' perspective developed by Barad (2003) and utilised extensively by Orlikowski (2007; 2010) and Orlikowski and Scott (2008b; 2012), has been challenged in the literature (Faulkner and Runde, 2012; Mutch, 2013; Leonardi, 2013; Kautz and Jensen, 2013). Conceptualising the social and material elements of everyday life as mutually constitutive is then considered to create empirical and operational problems (Styhre, 2011; Faulkner and Runde, 2012).

Significantly within the context of this research these issues include a lack of consideration to time and an inability to deal with broader social structures such as power (Mutch, 2013; Leonardi, 2013).

In order to address these perceived deficiencies Robey, Raymond and Anderson (2012, p.225) suggest that the revision of existing theories that nominally address or marginalise material features may be a useful strategy. Highlighted examples of this middle ground approach within the Information Systems (IS) literature are provided by Adaptive Structuration Theory (Markus and Silverman, 2008) and organisational routines theory (D'Adderio's, 2008; 2011).

Accordingly this research will contribute to theory through the development of a sociomaterial model based on the 'morphogenetic approach' (Archer, 1995) coupled to key tenets of ANT. The application of this model in practice will be utilised to bridge the gap between the design, implementation and use of LSPA within two UK pathology laboratories. In doing so this research asks a number of secondary research questions highlighted below:

- **Do the developers of LSPA purposefully intend their technologies to shape the work practices of users or the structure of organisations?**
- **If so how do designers of LSPA technology embody their intentions in designs?**
- **Do such design intentions subsequently have their effect in practice?**
- **If so why, if not why not?**

1.2 Overview of research design and methods

In order to explore the sociomaterial impact of LSPA, a social constructionist epistemology has been adopted, where meaning is developed through human interaction engagement and interpretation. From this interpretivist perspective, symbolic interactionism will be utilised to explore the shared understanding, feelings and attitudes of staff working in this environment. The methodology of choice for this form of investigation is considered to be that of multi-site ethnography due the researcher's role as an employee in both NHS organisations. From this standpoint a multi method approach has been taken, involving participant observation, undertaken during the course of routine working life. This research is supported by extensive data collection in the form of physical traces and primary and secondary archives (organisational documents, e-mail, process maps etc.). In addition, semi structured interviews and focus group interviews have been utilised to gather information, unavailable via participant observation. This data includes the views of both a number of pathology managers involved in the purchase of LSPA, together with those of the primary supplier of LSPA technology to both the sites under investigation. All of the interview data was subsequently coded and analysed using template analysis (King, 1998; Crabtree and Miller, 1999).

1.3 Structure of thesis

This section provides an overview of the thesis and a brief synopsis of each chapter, in order to provide context for the remainder of the work.

Chapter 2 explores the impact of technological determinism as the dominant paradigm within healthcare environment, manifesting itself as an on-going desire to adopt new technologies, including manufacturing style production systems. Within the context of this research, the UK government's pathology modernisation agenda is considered a primary driver for change. Technological determinism is then critically contrasted with more subjective approaches, which view technology as the product of on-going social interpretation and intervention. Ultimately both technological determinism and sociotechnical approaches are rejected in favour of a relational ontology, which rejects the notion that the world is composed in individuals with separately attributable properties (Orlikowski, 2010, p.134).

Chapter 3 discusses the development of relational ontologies, including the concept of 'sociomateriality' (Orlikowski, 2007, 2010; Orlikowski and Scott, 2008a), which considers the human and social to be an 'entanglement in practice' (Orlikowski, 2010, p.135). The chapter concludes with concerns raised in the literature that the concept of sociomateriality based on the 'agential realist' perspective developed by Barad (2003) fails to appreciate time and lacks a consideration of broader social structures including power (Mutch, 2013; Leonardi, 2013). In order to overcome these deficiencies the morphogenetic approach developed by Margaret Archer (1995) is proposed as a suitable alternative with which to bridge the gap between the design and use of fixed function technologies such as LSPA within a pathology environment.

Chapter 4 describes the research design, including the philosophical position underpinning this research, together with a structured framework to support the decision to adopt a multi-site ethnographic approach. The development of the interview schedule is then discussed together with the rationale for the semi-structured interview questions. Finally the ethical issues raised as a result of this research are addressed.

Chapters 5, 6 and 7 present the research data including the results of participant observation, textual data and template analysis of the semi structured interview transcripts. Chapter 5 focuses on the design intentions of the suppliers of LSPA, with regard to changes in working practices and organisational structures within user organisations. By contrast Chapter 6 focuses on the perceptions of pathology managers involved in the selection and procurement of LSPA technology. The chapter concludes with an assessment of the implementation and use of LSPA in practice within Organisation X. In Chapter 7 the impact of the material affordances and constraints of LSPA, observed within Organisation X are seen to manifest themselves within Organisation Y; the implications of which are observed to have a significant impact on both a ‘micro’ and ‘macro’ level.

Chapter 8 begins with the development of a sociomaterial model, based on the morphogenetic approach, developed by Margaret Archer (1995) coupled to key tenets of ANT. The development of this model is considered to overcome perceived limitations of the concept of sociomateriality based on the agential realist perspective developed by Barad (2003) including a failure to appreciate time and the influence of broader social structures. Ultimately it is suggested that a greater emphasis on collaboration between users, designers and corporate agents will result in innovative technology and improved organisational design.

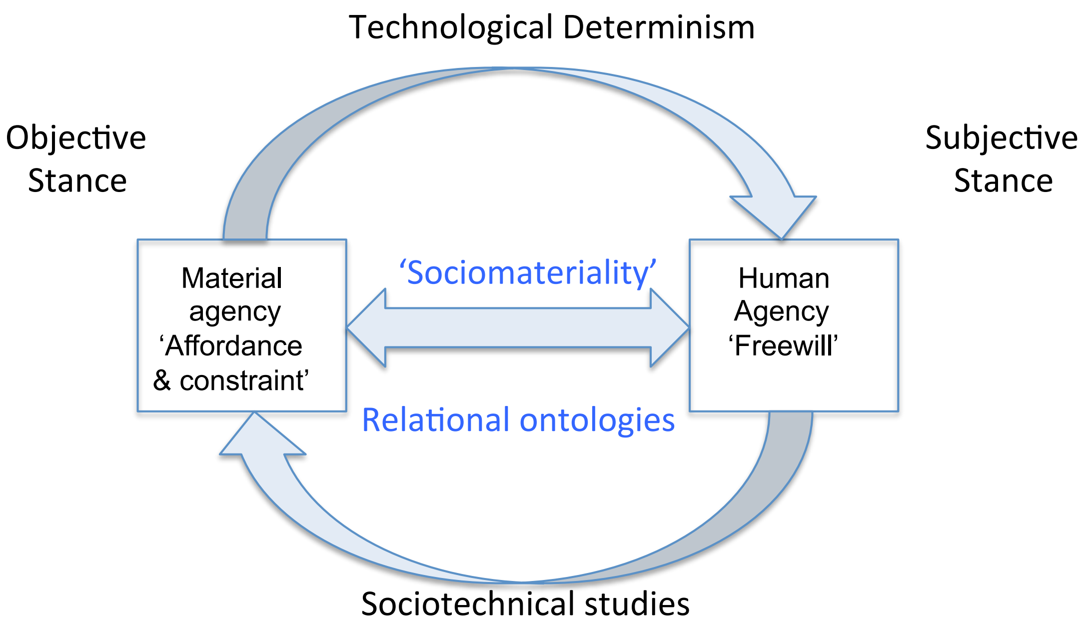
The concluding Chapter 9 highlights the contributions this research has made to theory and practice as well as acknowledging the originality, limitations and subsequent recommendations for future research.

Chapter 2 The impact of technological determinism and sociotechnical design within a health care environment

2.0 Introduction

This chapter aims to provide the academic context for the research and begins by critically reviewing the influence of both early contingency theorists and technological determinism within a healthcare environment. The technological deterministic perspective is then contrasted with the subsequent development of social theories of technology. Ultimately both of these perspectives are rejected in favour of a relational ontology, which does not consider the human and technical elements of society as being separate entities but rather considers them as being 'constitutively entangled in practice' (Orlikowski, 2007, p. 1437). A diagrammatic overview of the influence of technology on human action from an objective/subjective perspective is highlighted below to provide context for the following two chapters.

Figure 1. Overview of the objective/subjective debate on the influence of technology on human action



2.1 Technological determinism

According to Leonardi and Barley (2008, p.162) ‘technological determinism entered organisational studies with the work of early contingency theorists’ (Woodward, 1965; Harvey, 1968; Perrow, 1967; Khandwalla, 1974; Carter, 1984). This perspective views technology as any ‘exogenous force, which determines or constrains the behaviour of individuals and organisations’ (Markus and Robey, 1988, p. 585). The pioneering work of Woodward (1958; 1965) led to the conclusion, that ‘different technologies imposed different kinds of demands on individuals and organisations, and that these demands had to be met through an appropriate organisational form’ (Leonardi and Barley, 2008, p.162). Within the contingency theory model, formal organisation or organisational structure is considered ‘stable’ and explicit patterns of ‘prescribed relationships’ are considered to exist inside the organisation, defining job role, authority, responsibility and accountability (Woodward, 1965, p. 10). Within this model it is acknowledged that no account is made of the ‘social process’, which goes on inside any institution and results in the establishment of ‘informal organisation’ (Woodward, 1965, p. 10).

The contingency theorists agenda was then ‘to devise a set of principles about (if not an actual theory of) technology and organisations which would hold across all organisations and all technologies’ (Orlikowski and Barley, 2001, p.148).

Contingency theorists however viewed technology in ‘one of two abstract ways’ both of which paid very little attention to artefacts ‘identifiable material properties’ (Leonardi and Barley, 2008, p.162). Firstly technology was considered as a ‘production system’ (Leonardi and Barley, 2008, p.162; Orlikowski and Barley, 2001, p.148), with a particular focus on custom, small batch, large batch and continuous manufacturing' (Orlikowski and Barley, 2001, p.148). Here technology is comprised of people, processes and machines coordinated to transform inputs into outputs (Leonardi and Barley, 2008, p.162). Within this context technology is considered to be an 'independent variable, and the arrangements among people for getting work done a dependent variable' (Perrow, 1967, p. 195).

Secondly others 'sought a set of broad dimensions or attributes to compare technologies regardless of their purpose or design' (Orlikowski and Barley, 2001, p. 148). These included the 'routinisation of process' and the 'schematics for dealing with exceptions' (Perrow, 1967, p.195), vertical integration, decentralisation and the use of sophisticated controls (Khandwalla, 1974, p.74), and participative supervision (Mohr, 1971).

These factors are in stark contrast to contemporary studies of technology, which define their object of study more narrowly, identifying artefacts such as mobile phones (Arnold, 2003; Juris, 2008; Hislop and Axtell, 2011), e-mail (Ruggari-Stevens and McElhill, 2000), e-commerce (Dampour, 2001; Gaertner and Smith, 2001; Lee and Wang, 2001) and Enterprise systems (Soliman and Youseff, 1998; Sommers and Nelson, 2001; Akkermans and Van Heldon, 2002).

Included in this list are information technologies which although not having visible material properties do provide 'opportunities for constraints on action' (Leonardi and Barley, 2008, p.162). Information Technology is therefore considered to have materiality in a sense that production systems do not.

According to Orlikowski (1992, p. 400) although contingency theory contributed to an understanding of technologies often determining effect on organisations, this body of research largely ignores the action of humans in 'developing, appropriating and changing technology'. Whilst at the same time overlooking the way 'social systems shape technology and its use' (Leonardi and Barley, 2010, p. 4). Indeed Leonardi and Barley (2008, p. 162) state that 'the genius of early sociotechnical systems theory was to show that the same forces of production (technology) could actually support different social arrangements (Emery, 1959; Rice, 1953; Trist and Bamforth, 1951).

2.2 Technological determinism in Healthcare

The concept of the 'technologic imperative' within healthcare was first identified decades earlier by economist Victor Fuchs (1968, p.193) as highlighted below:

> *'medical tradition emphasises giving the best possible care that is technically possible; the only legitimate explicitly recognised constraint is the state of the art'. He goes onto conclude goes that almost uniquely within healthcare as opposed to other manufacturing and service industries there is a 'deep reluctance to weight cost against benefit' (Fuchs, 1968, p.193).*

Wolf and Bishop-Berele (1981, p.125) conclude that technological determinism is the dominant paradigm with 'bioscience' as highlighted below:

> '*What has become abundantly clear, by both assertion and implication, is that the term "technological imperative" is all too appropriate. What began as simple tools and purely effective extensions of the physicians personal approach to the patient have especially in the last 80-100 years, become intrinsic, self-propagating, requisite and almost autonomous elements of today's biomedicine'*

Timmermans and Berg (2003, p.101) suggest that the technological deterministic viewpoint ‘enforces medical social control’ and the notion that technology is the ‘driving force in late modern societies’. The group go on to highlight that technological determinism comes in different strengths. Strong technological determinists, such as the radical feminist Elaine Denny (1994) argue that ‘technology develops as a result of an internal dynamic, moulding society to fit logical patterns’ (Timmermans and Berg, 2003, p.101). In this example, Denny (1994, p.62) investigates the impact of in-vitro fertilisation, considered in this context as the ‘control of women’s reproductive role by men as being the ‘root of patriarchal oppression’. Weaker versions of technological determinism view technology as a ‘political tool’, such as the introduction of Deoxyribonucleic Acid (DNA) technologies as being abused for political or economic ends as well as raising concerns about psychological harm and discrimination (Nelkin and Andrews, 1999, p. 659). The influence of technology as a political tool will be highlighted below, as part of the UK government agenda to modernise pathology services.

2.2.1 Technological determinism within UK NHS Pathology Laboratories

According to the UK Government, pathology services ‘lie at the heart of the health care services’ provided to patients and are ‘essential to the delivery of many of the national priorities and targets for the NHS’ (Great Britain. Department of Health, 2006, p.5).

The UK government define pathology services as ‘a clinically led diagnostic, laboratory and post mortem services based in an NHS Trust’ (Great Britain. Department of Health, 2004, p.7).

This includes ‘direct patient care, interpretation and clinical liaison’ (Great Britain. Department of Health, 2004, p.7). Pathology services include tests on blood and other human materials necessary for diagnosis and monitoring of a wide range of clinical conditions.

According to the UK government funded review of pathology services by Lord Carter of Coles (Great Britain. Department of Health, 2006) it is estimated that 70-80% of all health care decisions affecting diagnosis or treatment involve a pathology investigation. It is estimated that pathology services cost the NHS an estimated £2.5 billion per annum, of which the single largest element is the workforce (Great Britain. Department of Health, 2006, p. 5).

In 1999 the UK government launched the Pathology Modernisation programme, with the key goals of ‘improving quality and efficiency’ and ‘encouraging the introduction of new technologies’ (Great Britain. Department of Health, 2002, p. 3). This document highlighted the effects of ‘decades of under-investment’ (Great Britain. Department of Health, 2002, p.4) coupled to increasing demand for Pathology services. Specific pressures were noted including a ‘shortage of staff at all levels and in all disciplines’ coupled to an ‘ageing workforce’ (Great Britain. Department of Health, 2002, p.4). It was also noted that ‘new technical and scientific developments require ‘new skills and new ways of working’ (Great Britain. Department of Health, 2002, p.3).

The UK Government's vision for NHS Pathology was communicated as follows:

> *'a service designed around patients' needs, providing fast, high quality diagnosis and supporting good clinical practice with good outcomes for patients. We need to look at services from a patients point of view and ask what they want, how we can deliver it, and what will improve their experience of being tested' (*Great Britain. *Department of Health 2002 p.5)*

In order to deliver a modernised Pathology service the concept of the formally managed Pathology Network was introduced by the Department of Health in 2002 (Great Britain. Department of Health, 2002). The document states that 'the traditional image of the District General Hospital (DGH) as the principal provider of healthcare is no longer accurate' (Great Britain. Department of Health, 2002, p.6). Individual Trust based pathology laboratories were considered an inappropriate platform, with which to deliver a patient focused service, requiring 'improved access to testing in different settings' and 'increased specialisation' (Great Britain. Department of Health, 2002, p.6). The adoption of informal networks were considered inadequate, as they were considered to seldom go far enough to deliver change fast enough and to struggle to make their arrangements clear enough for clinical governance' (Great Britain. Department of Health, 2002, p.7). A key feature of a formally managed pathology network would be 'a single integrated management structure and budget' serving a population equivalent to those served by Strategic Health Authorities' (Great Britain. Department of Health, 2002, p.7). Although not considered synonymous with centralisation, benefits in quality and efficiency were deemed possible by consolidating some aspects of the service into a smaller number of sites (Great Britain. Department of Health, 2002, p.7). Key enablers to this political strategy were integrated pathology information systems (IS) and the application of new technology to 'automate processes', ‘deliver services’ and ‘transfer information’ (Great Britain. Department of Health, 2002, p.11).

In order to facilitate the introduction of these ‘new technologies’ (Great Britain. Department of Health, 2002) the UK Government formed the Pathology Improvement Service team to investigate the application of ‘lean methodology’ (Krafcik, 1988, p.44; Womack, Jones and Roos, 2007) developed from the Toyota Production System (TPS) (Monden, 1994; Ohno, 1998; Liker, 2004). The development of lean manufacturing principles is then reminiscent of our understanding of technology as a ‘production system’ developed from the early contingency theorists (Woodward, 1965; Harvey, 1968; Perrow, 1967; Khandwalla, 1974; Carter, 1984). Within this context lean principles are proposed to be applicable across organisational boundaries.

Within the literature there are a massive array of examples of lean principles within a healthcare environment reportedly contributing to improved quality (Radnor and Boaden, 2008; Campbell, 2009; Aherne, 2007, Katz-Navon, Naveh and Stern, 2007), enhanced safety (Ben-Tovim et. al. 2007, p.14), reduced waiting times (Ben-Tovim et. al. 2007 p.14; Jones and Filochowski, 2006; Kollberg, Dahlgaard and Bremer, 2006, p. 7); improved diagnostic specimen turnaround times (Persoon et. al. 2006) and reduced levels of hospital acquired infections (Balle and Regnier, 2007). According to Jones and Mitchell (2006, p. 23) the lean message within healthcare is ‘100% positive’.

During this period there have also been many published examples of lean initiatives contributing to operational efficiency in a pathology environment. A discipline specific review is highlighted in table 1 below:

Table 1 Lean initiatives within pathology laboratories

Pathology discipline	Principal activity	Reference
Biochemistry/ Haematology	Pre-analytic sample sorting using process mapping and one piece flow, standardised working, visual controls	Chomyn and Fottles (2011); Hamer (2011); Jones and Mitchell (2006); Westwood and Silvester (2007)
Histology	Waste reduction, one piece flow and the introduction of pull systems	Clark and Chomyn (2010)
Blood Transfusion	Process mapping, integrated supply chains reduced waste	Shaw and Gray (2011) Chynoweth (2011)

Using these positive early results a further recommendation for the use of ‘lean’ came from Lord Carter in his review of NHS Pathology Services in England (Great Britain. Department of Health, 2006). Lord Carter suggested that techniques such as ‘lean and ‘six sigma’ (a statistical process control technique often used in conjunction with lean), could be used within a ‘managed pathology network’ to ‘optimise the efficient and effective management of processes’ (Great Britain. Department of Health, 2006, p.13).

The subsequent second phase review of pathology services estimated that ‘consolidation of services’ within a managed pathology network could achieve potential annual savings of between £250-500million (Great Britain. Department of Health, 2008, p.18). The figure of £250-500 million was further reiterated as Pathology services were brought under the UK Government’s Quality Innovation, Productivity and Prevention (QIPP) agenda (Great Britain. Department of Health, 2009, 2010a, 2010b). In 2010 Pathology services were identified as a National QIPP work stream lead by Dr Ian Barnes, National Clinical Director of Pathology. During 2010 Dr Barnes stated that NHS Improvement had been commissioned to deliver a national ‘lean’ programme and once again suggested that the implementation of ‘lean’ could achieve significant savings within laboratories by ‘stripping out waste’ (Barnes, 2010).

In practice the application of lean has shown considerable variability from system wide approaches, Virginia Mason (Seattle) (Albright, 2008), Flinders (Adelaide) (Ben-Tovim et. al. 2007), Bolton (UK) (Fillingham, 2007) to more localised departmental application (Ballé and Réginer 2007, NHS Institute for Innovation and Improvement 2007; Esain, Williams and Massey, 2008). The huge variation in the scope and scale of lean initiatives across the healthcare environment illustrates that the ‘wider socio-cultural and organisational context of healthcare can have a significant bearing on how lean is translated in practice’ (Waring and Bishop, 2010, p.1333). Equally, the wide variation of application and scope of lean principles makes external academic review problematic (Proudlove, Moxham and Boaden, 2008, p.27), with a bias towards ‘favourable results’ (Joosten, Bongers and Jansen, 2009, p.341). The adoption of lean principles within healthcare appears to involve ‘ad hoc practices’ which ‘fail to indicate that the process is particularly or exclusively lean’ (Young and McLean, 2009, p. 309).

2.3 Criticisms of technological determinism in healthcare

According to Barger-Lux and Heany (1986, p. 1314) technological determinism is deeply rooted in a culture, which emphasises ‘positive action to sustain and prolong life’. It would appear than once a clinical decision has been made to intervene; even when there is no chance of sustaining the life of the individual it becomes increasingly difficult to resist further action. Hofmann (2002, p.677) states that ‘these decisions are incompatible with reasonable expectations of net benefit’. Timmermans and Berg (2003, p. 100) state that the ‘evil technological forces here are anaesthesia and intubations required for artificial ventilation prolonging the dying process in sterile, alien environments'.

Hofmann (2002, p.679) concludes that 'diagnostics' incorporating both pathology laboratory and radiology reflect the most inappropriate use of technology where it is used 'far beyond that which is necessary'. Consequently technology is a factor in competition between hospitals where the acquisition of state of the art equipment would appear to be highly esteemed by both the public and professionals (Hofmann, 2002, p.683). This factor is coupled with a fear of legal action if possible action is withheld (Barger-Lux and Heany, 1986, p.1314; Hofmann, 2002, p. 682)

The clinical desire for new equipment has then shifted the goal of medicine from 'caring for sick people to merely diagnosing disease' (Hoffmann, 2002, p.678). The spread of technology within bioscience is considered by Davidson (1995, p.52) to be nothing more than a form of 'technological cancer' enveloping healthcare.

Barger-Lux and Heaney (1986, p. 1315) conclude that possibly the greatest pressure to adopt a technological imperative within healthcare, comes from the expectations of the patients themselves. Here quality of care is equated in terms of 'highly sophisticated services' including the 'application of many and frequent diagnostic tests and the performance of equipment bound procedure' (Barger-Lux and Heaney, 1986, p. 1315). Hofman (2002, p. 677) identifies that patients have become 'more educated', a factor that has become even more prevalent and challenging to clinical staff with the rise of the Internet (Castleton et.al. 2011; Hartzband and Groopman, 2010; Sechrest, 2010).

According to Timmermans and Berg (2003, p.100) the main theoretical limitation of technological determinism in a healthcare environment is one of 'reductionism', where technology is ascribed 'super powers', which are unsubstantiated in practice as highlighted below:

> *'a closer look at medical technologies indicates that technological determinism is 'fuelled by a suspicious blend of case selection and conspiracy theories' extending the clear-cut influence of some groups. They go on to suggest that the resulting 'big roar and black smoke' result in little 'analytical movement' and hence it would be 'good to retire technological determinism once and for all' (Timmermans and Berg, 2003, p. 101).*

In the following section of this chapter the alternate subjective view of technologies influence on social structure will be reviewed under the umbrella of the 'strategic choice model' (Orlikowski, 1992).

2.4 The 'strategic choice' model

The 'strategic choice model' according to Orlikowski (1992, p. 400) 'suggests that technology is not an external object, but the product of on-going human action, design and appropriation' and within this perspective three research foci are identified.

The first research foci emphasises how a particular technology is physically constructed through the social interactions and political choices of predominately powerful human actors (Orlikowski, 1992, p. 400). Here technology is considered to be a dependent variable, most notably 'contingent on those individuals that have the power to direct the organisation' (Child, 1972, p.2). Within this framework strategic choice extends to the 'context within which the organisation is operating', 'the standards of performance' economic constraints' and the 'design of the organisational structure itself' (Child, 1972, p.2).

Particularly relevant here are sociotechnical studies (STS) originally devised by researchers working for the Tavistock Institute, investigating long wall mining techniques within the North Durham coalfields (Trist and Bamforth, 1951: Trist et al. 1963). This group concluded that although technology places constraints and affordances on organisational design, 'social and psychological properties' must be given equal consideration in order to attain 'optimum conditions for the system as a whole' (Trist et al. 1963). According to Mumford (2006, p. 318) 'technology should not be the controlling force when new systems are implemented, they believe equal attention should be paid to providing a high quality and satisfying work environment'.

Within this context Sociotechnical design is considered to be more of a 'philosophy' than a 'methodology' equating to a 'humanistic set of principles associated with technology and change' (Mumford, 2006, p.317). Importantly sociotechnical design also has a democratic component in that 'employees should be involved in determining the required work life improvements' thus alleviating a lack of personal control which resulted in 'alienation and job dissatisfaction (Mumford, 2006, p.317). Sociotechnical design principles were constantly added to during the 70's, a summary of which can be seen in table 2 below:

Table 2 Sociotechnical design principles adapted from Cherns (1976)

Principle	Key features
Compatibility	The process of design should be compatible with its objectives.
Minimal Critical Specification	No more should be specified than absolutely necessary, but the essential must be specified
The Socio-technical Criterion	Variances from the expected norm must be controlled as close to the point of origin as possible. Problems of this kind should be solved by the group that experiences them and not by another group such as supervisors
Multi-functionality	Workers need to be multi skilled for adaptability and learning
Boundary location	Boundaries should occur where there is a natural discontinuity – time, technology, change etc.
Information	Must go in the first place where it is needed in action not relayed by management
Support Congruence	Systems of social support must be designed to reinforce the desired social behaviour
Design and Human Values	High quality work requires: Jobs to be reasonably demanding Opportunity to learn An area of decision making Social support The opportunity to relate work to social life A job that leads to a desirable future
Incompletion	Design is an iterative process, which never stops.

Key concepts included the role of multi-functionality, as opposed to the ‘multi-tasking’ observed in lean production (Niepce and Molleman, 1998, p.266). Within STS workers would be trained to develop a multitude of skills, which would act as a buffer against unexpected events such as staff absence.

Another key concept was that of 'minimal critical specification', which states that 'no more should be specified than is absolutely essential', but that the 'essential must be specified' (Cherns, 1976, p.786). This is often conveyed as 'giving groups clear objectives without formally stating how they will achieve them' (Mumford, 2006, p 322).

According to Mumford (2006) the rise of sociotechnical methods reached a peak in the 70's but interest diminished due to 'powerful economic climates and technically deterministic cultural pressures'. A review of the literature reveals that few organisations during this period could sustain the sociotechnical concept and few had any long-term success (Adler and Cole 1993; Kuiper's, Dewitt and Van der Zwann, 2004; Berggren, 1994; Rehder, 1992; Engström et al. 1995)

Despite these challenges STS principles have been adopted in a number of organisational settings, including the research and development sector (Keating, et al. 2001), healthcare, (Harteloh, 2003; Carayon, 2012), Information Technology (IT) integration and knowledge construction, (Shani and Sena, 1994; Cartelli, 2007) and computer aided engineering, (Purser, 1992). According to Kumpe and Bolwijn (1994) and Molleman and Broekhuis (2001, p.272) the application of STS principles is considered to be strategically advantageous, when innovation rather than price is the key performance indicator.

2.4.1 Sociotechnical design in Healthcare

According to Chisholm and Ziegenfuss (1986, p.315) 'healthcare delivery is an industry with a significantly complex mixture of technical and social components, and one particularly well suited to STS'.

Drawing on his experience with the development of an EPR on an ICU, Berg (1999a, p.88) states that ‘socio-technical approaches put people and their working relationships centre stage and form a long-needed antidote to the technology centred top-down approaches’. He goes on to state that in current times the term has drifted away from the ‘direct focus of workers emancipation’ and now embraces a ‘user orientated perspective’ (Berg, 1999a, p.88).

Specifically Berg (1999a, p.89) argues that STS is an appropriate approach to facilitate the introduction of Information Technology (IT) applications in healthcare, for which he gives three reasons. Firstly he argues that importantly the elements that make up this network, both human and material, should not be considered to be discrete; rather these entities only acquire specific characteristics as part of the network, accordingly ‘without nurses, record systems or the stethoscope the medical doctor as we know it could not exist’ (Berg, 1999a, p.89).

Secondly Berg (1999, p. 89) states that although much of the work is routinised including the production of ‘pathology results’, healthcare by its very nature ‘is not predictable and contains a great deal of inherent variability. A great deal of this inherent variation is created by the unpredictable nature of patients themselves (Berg, 1999a, p.89; Chisholm and Ziegenfuss, 1986, p. 319). The patient-physician interface is considered to be a unique setup, which requires a ‘high degree of discretion, on the spot decision making and versatility’ (Katz-Navon, Naveh and Stern, 2007). This variation is accommodated by ‘on-going negotiations between staff, via distributed decision making, multiple view points’ and by its ‘inconsistent and evolving knowledge base’ (Berg, 1999a, p. 88).

Finally this on-going negotiation or ‘articulation’ can be viewed as a ‘work around to get the job done in the face of local contingencies’. Within this context, on the job negotiation between clinical staff is considered the ‘glue’ that holds the complex work practices together, ‘invisible to outsiders’ and ‘not highly valued by management’ (Berg, 1999a, p. 88)

Drawing on their experience of the development of an EPR (Berg, et al. 1998, p. 234) advise that the system should not be ‘overtly structured’, but should ‘yield immediate benefits for end users supporting work and not generating it’.

The sociotechnical requirement to involve system users was also highlighted by Eason (2007) in his review of the development of the EPR within the UK NHS National Programme for IT (NpfIT). Where users of the system could identify clear benefits such as the implementation of the Picture Archiving and Communications System (PACS) within Radiology it appears to be a ‘success story in the making’ (Eason, 2007, p. 259). However the introduction of the Choose & Book system designed to improve patient access or the development of the integrated health care record appears fraught with partial use, workarounds, failure and delay (Daggett, 2006; Pothier, et al. 2006; Collins, 2008; Currie and Finnegan, 2011; Jenkings, 2004). The root cause of the problem appears to be a ‘lack of flexibility within the system, a failure to understand local workflows and a technologically deterministic approach to implementation’ (Eason, 2007, p. 262).

Within a pathology environment a great deal of sociotechnical research has been undertaken to assess the impact of Computerised Physician Order Entry (COPE). These systems allow clinical staff to enter requests including Pathology, Radiology and Pharmacy directly onto an IT system without the requirement for a hand written request card. As such COPE systems are considered to significantly improve quality and patient safety (Tierney, Overhage and McDonald, 1996; Kuperman and Gibson, 2003, p.31; Georgiou and Westbrook, 2006; Bates et al. 1999; Roshanov et al. 2011; Ash et al. 2003, p.235).

A failure to address the sociotechnical implications of the introduction of COPE, including differing working practices, user requirements and clinical workflows resulted in 'organisational chaos' within a Dutch University Medical Centre (Aarts, Doorewaard and Berg, 2004, p.213; Niazkhani et al. 2009; Aarts, 2010; Peute et al. 2010).

Pasmore, Petee and Bastian, (1986) studied the effects of sociotechnical design directly within a Pathology laboratory. The main focus of this work was the introduction of new technology within the departments of Biochemistry and Microbiology.

Following the application of a diagnostic survey administered to all technologists in the two departments, minor structural changes were introduced into the laboratory including a clarification of job descriptions, improved training and job rotation. Within the Biochemistry department many staff were of the opinion that the introduction of technology had simplified the job to the point that 'technically trained high school students could perform it' (Pasmore, Petee and Bastian, 1986, p. 330).

Analysis of the post implementation survey concluded that job satisfaction; motivation and security fell appreciably during the intervention. The cause of these concerns was noted as 'continued automation' and the 'constant pressure to reduce laboratory costs' including the 'on-going threat of outsourcing work to the private sector' (Pasmore, Petee and Bastian, 1986, p.3 32).

Despite the apparent failure of the project however the authors believe that STS is appropriate in a healthcare setting noting two exceptions to support this conclusion. In the first case when the supervisor of the reception area took maternity leave the remaining technicians began to work as an 'autonomous unit using self-regulation and group problem solving techniques' (Pasmore, Petee and Bastian, 1986, p. 336). Secondly technologists working on the third shift (21:00-7:00) demonstrated significant improvements in productivity when compared to the routine hours. It is argued that situation posed 'fewer structural barriers to workers, and 'allowed staff to utilise a wider range of skills' (Pasmore, Petee and Bastian, 1986, p. 336).

This research also highlighted a cultural divide between clinical staff and medical technologists, noted elsewhere in the literature (Valentine and Behara, 2001; Wainwright and Shaw, 2007, 2008, 2013). This cultural divide was considered to centre on the 'delegation and release of power' created by demarcations in educational requirements, and professional codes supported by legal and regulatory realities' (Pasmore, Petee and Bastian, 1986, p. 337).
In order to address this dilemma, (Pasmore, Petee and Bastian, 1986, p. 338) conclude that future STS experiments must focus on either changing the organisational culture to accommodate 'innovative work arrangements' or finding ways of bringing about social and technical 'innovation while maintaining cultural continuity'. In order to change organisational culture, the group suggest 'employing an external consultant' or 'technical expert' capable of 'overcoming the cultural norms favouring specialisation' (Pasmore, Petee

and Bastian, 1986, p. 339). The alternative recommendation is to nurture sources of innovation existing within the system such as the examples identified following the removal of the supervisor in the accession area and the behaviours observed during the third back shift. Making leaders aware of such alternative arrangements is suggested as a means of helping an organisation expand its range of alternatives by ‘building upon and learning through its own strengths’ (Pasmore, Petee and Bastian, 1986, p.339).

2.4.2 Technologies ability to automate or informate

The ability to ‘build upon and learn through an organisation’s own strengths’ (Pasmore, Petee and Bastian, 1986, p. 339) has been considered by Zuboff (1988) with regard to the role of Information Technology (IT) on organisational design. A primary consideration within this body of work is the ability of IT to both ‘automate’ and ‘informate’ a process (Zuboff, 1988, p. 8). All computer-controlled processes such as those found within an automated pathology laboratory, have first to be broken down to their individual constitutive parts. Software is then used to ‘automate’ (Zuboff, 1988, p.8) the individual components in a rationalised, predictable and precise manner, unachievable by the human hand. At the same time the substitution of automation for human action facilitates the collection of data at each stage of the process. In this context ‘activities, events and objects are translated into and made visible by information when a technology informates as well as automates’ (Zuboff, 1988, p.10). The application of IT to merely automate a process will in effect simply decrease the dependence on human skills. If on the other hand the same technology is used to ‘informate’ it ultimately sets in motion a ‘series of dynamics that will ultimately reconfigure the nature of work and social relationships that organise productive activity’ (Zuboff, 1988, p.11).

2.4.3 Deficiencies of the sociotechnical perspective

According to Orlikowski (1992, p. 401) the sociotechnical studies rely too much on the 'capabilities of human agents'. As a result the appropriation and deployment of a technology depends on 'social and economic forces beyond managerial intent', which may 'thwart any intended reconstruction of jobs and technology'. Some of these forces include 'institutional properties of the organisation, micro politics of the workplace, features of the environment, and unintended consequences of organisational change' (Orlikowski, 1992, p. 401).

2.5 Social Constructionism

The second stream of research, within the strategic choice model, is that of the social constructionists who draw inspiration from the work of a number of sociologists of science, who began to study technology in the 80's (Pinch and Bijker, 1984; Woolgar, 1985; Bijker, 1993, 2010; Pinch, 2008). The social constructionists identified within this approach seek to explain how 'the interests and perspectives of individuals and groups shape the design and meaning of technological systems' (Orlikowski and Barley, 2001, p. 149).

Following the introduction of technology 'social groups will eventually construct and share similar realities that they take for granted as neutral, efficacious and necessary' (Leonardi and Barley, 2008, p. 169).

During the 80's the influence of social constructionism developed into the science, technology and society movement. This programme commonly labelled the constructivist studies of technology are premised on the central adage that 'one should never take the meaning of a technical artefact or technological system as residing in the technology itself' (Bijker, 1995, p.6). Instead one must study how technologies are shaped and acquire their meaning in the heterogeneity of social interactions' (Bijker, 1995, p.6). Bijker (1995, p.6) goes onto state that within the constructivist research programme, we can distinguish three lines of work, the systems approach, the actor network approach and the social construction of technology (SCOT) approach.

Within SCOT the term 'interpretive flexibility' is used to describe how artefacts are 'culturally constructed and interpreted' by both users and designers of the artefact (Pinch and Bijker, 1984, p.421). This social construction and cultural interpretation extends from the design phase to the users of technology who in turn can modify and shape the artefact in ways unintended by the manufacturer. In doing so Bijker (1995, p.3) states the following:

> *'Technology is created by engineers working alone or in groups, marketing people who make the world aware of new products and processes, and consumers who decide to buy or not to buy and who modify what they have bought in directions no engineer has imagined'. 'Technology is thus shaped not only by social structures and power relations, but also by the ingenuity and emotional commitment of individuals'.*

However Orlikowski and Barley (2001, p.149) state that 'researchers adopting this perspective have yet to examine how agency shapes the way technology influences both work practices and organisational structure once the technology is deployed in organisations'. This group argue that the social construction movement has gone too far in rejecting the concept of 'materiality' and 'material affordances and constraints' (Orlikowski and Barley, 2001, p.149). By considering technology to be simultaneously 'physical and social' neither a materialistic or constructivist stance adequately addresses the influence on organisational structure (Orlikowski and Barley, 2001, p.149). In addition conceptual difficulties arise within the social construction movement concerning the issue of technologies 'stabilisation' (Bijker, 1995, p.84) over time. The notion of stabilisation fails to consider how users may modify a technology following its introduction.

2.6 Marxist account of technology

The third stream research within the strategic choice model is the Marxist view of technology (Garrahan and Stewart 1992; Post and Slaughter 2000). This perspective outlines the manner in which technology is devised and deployed 'to further the political and economic interests of powerful actors (the social construction of technology at the point of use)' (Orlikowski, 1992, p. 401). These studies, however, fail to account for the 'diverse ways in which technology is appropriated and utilised by workers' and the 'non uniform manner with which it structures individual and organisational action' (Orlikowski, 1992, p. 401).

2.7 Model of technology as a trigger for structural change

According to Orlikowski (1992, p.402) the third perspective on the relationship between technology and organisational structure is exemplified by Barley (1986). Utilising structuration theory (Giddens, 1984) to conceptualise the relationship between human agency and organisational structure, Barley (1986) investigated the impact of identical Computerised Tomography (CT) scanners into two similar sized Radiology departments in Massachusetts.

This research revealed that following the introduction of the technology, one site become far more 'decentralised' relative to the other, with regard to decision-making and the flow of information (Barley, 1986, p.103). This decentralisation resulted in a role reversal, whereby information in the suburban site flowed from technologists (Radiographers) to medically qualified

Radiologists, thus challenging the traditional professional dominance of the latter.

In conclusion it is suggested that ‘technologies do influence organisational structures in orderly ways, but their influence depends on the specific historical process in which they are embedded’ (Barley, 1986, p.107). As a consequence it becomes ‘unsound practice to lump together organisations with radically different institutional histories and ecological milieu’ (Barley, 1986, p.81). This factor has significant consequences for the pathology modernisation agenda, which is premised on wide-scale centralisation of pathology laboratories.

2.8 A Structurational model of technology

While many researchers have used structuration theory (Barley, 1986; De Sanctis and Poole, 1994; Riley, 1983; Ranson, Hinings and Greenwood, 1980; Sewell, 1992; Pozzebon, 2004; Jones, Edwards and Beckinsale, 2000; Lewis and Suchan, 2003) as a framework to understand organisational processes, Giddens (1984) does not explicitly address the issue of technology. However in the structurational model of technology developed by Orlikowski (1992, p.405) technology is considered to be an ‘instantiation of some of the rules and resources constituting the structure of organisation’.

2.8.1 The duality of technology

The concept of the ‘duality of technology’ considers technology to be both the product of human action, while at the same time assuming structural properties. Within this framework technology is considered to be physically constructed by ‘actors who are working in a given social context’, whilst at the same time being ‘socially constructed by users who may well attach different meanings to the individual features’ (Orlikowski, 1992, p. 405). Once deployed however technology often becomes ‘reified and institutionalised’ (Orlikowski, 1992, p. 405), losing its connection with the users who gave it meaning and thus becoming part of the structural properties of the organisation. According to Orlikowski (1992, p.406) ‘agency and structure are not independent’. It is the on-going action of human agents interacting with a technology that ‘objectifies and institutionalises it’ (Orlikowski, 1992, p.406). Constant recreation or re-interpretation of technology would however negate many of technologies’ obvious advantages such as the ‘assumed stability’ (Orlikowski, 1992, p.406) necessary for institutionalisation. However there are clearly occasions where ‘continued unreflective use of a technology is inappropriate or ineffective’ (Orlikowski, 1992, p. 406).

2.8.2 The interpretive flexibility of technology

The second premise within the structurational model of technology is that of ‘interpretive flexibility’ in so much that ‘interaction of technology and organisations is a function of the different actors and socio-historical context, implicated in its development and use’ (Orlikowski, 1992, p. 405).

According to Orlikowski (1992, p. 407)

> *‘many of the actions that constitute a technology are often separated in time and space from the actions that are constituted by the technology, with the former typically occurring in vendor organisations, and the latter occurring in customer sites’.*

Rather than positioning the phases of design and use within a technologies lifecycle as distinct entities, the structurational model of technology ‘posits artefacts as modifiable throughout their existence’ (Orlikowski, 1992, p. 408). Within this model even the most “black box technologies” (like those observed within the medical profession) have to be ‘apprehended and activated’

(Orlikowski, 1992, p. 408) by human agents thus facilitating a degree of interpretive flexibility of use. Within this model the term interpretive flexibility denotes the degree to which users of technology are engaged in its constitution (physically and or socially) during its development or use. Within this context, examples of technological sabotage or degrees of avoidance (Perrow, 1983; Zuboff, 1988; Markus, 1994) also illustrate the role of agency in shaping the use of technology. As such interpretive flexibility is influenced by 'characteristics of the material artefact', 'characteristics of the human agents e.g. experience and motivation' and 'characteristics of the context (e.g. social relations, task assignment, resource allocation' (Orlikowski, 1992, p. 408). The fundamental elements of the structurational model of technology are summarised in Figure 2 and Table 3 below.

Figure 2 The Structurational model of Technology adapted from Orlikowski (1992, p.410)

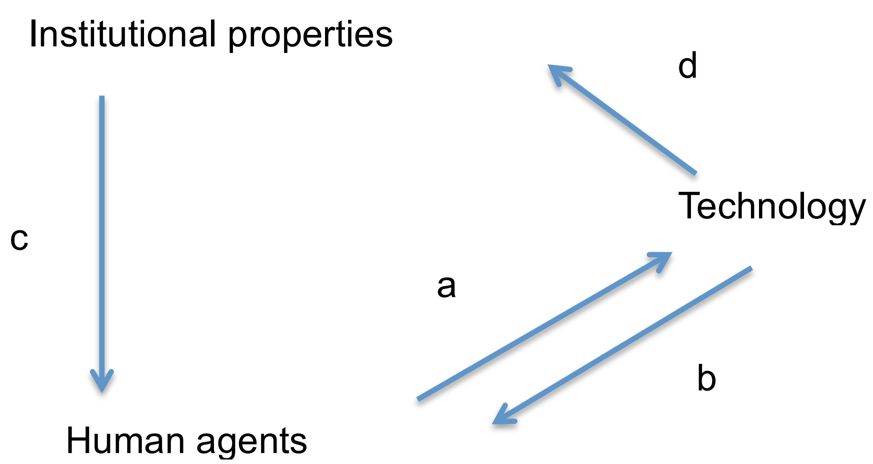


Table 3 The Structurational model of Technology adapted from Orlikowski (1992, p.410)

Arrow	Type of Influence	Nature of influence
a	Technology as a product of human action	Technology as an outcome of such human action as design, development, appropriation and modification
b	Technology as a medium of human action	Technology facilitates and constrains human action through the provision of interpretive schemes, facilities and norms
c	Institutional conditions of interaction with technology	Institutional properties influence humans in their action with technology, for example intentions and professional norms,
d	Institutional consequences of interaction with technology	Interaction with technology influences the institutional properties of an organisation, through reinforcing or transforming structures of signification, domination and legitimation

Orlikowski (1992) utilises the structurational model of technology to assess the impact of the internal design and use of computer-aided software engineering (CASE) technology in a large multi-national corporation. During this work, she re-emphasises that the institutional properties and human agency involved in the creation and development of technology will potentially play a role in shaping the structural properties and working practices of those organisations utilising the technology.

As a consequence, only technologies that are actually utilised in practice can be considered to structure human action as they are ‘implicated in the rules and resources in the constitution of a particular recurrent social practice’ (Orlikowski, 2000, p.407). Seen through a ‘practice lens’ (Orlikowski, 2000, p.407) technology structures are ‘emergent’ not ‘embodied’. Rather than focusing on structures presumed to be embedded within technology, she proposes an alternate view, examining how ‘human action enacts emergent structures' (Orlikowski, 2000, p.407), through recurrent use of technology. The so-called 'technology-in-practice' thus refers to the 'specific structures routinely enacted as we use each specific machine, technique, appliance device or gadget in recurrent ways in our everyday situated activities' (Orlikowski, 2000, p.408). As a consequence, the functions of a given technology can be 'personally edited' by being experienced 'differently by different individuals and differently by the same individuals depending on the time or circumstance' (Orlikowski, 2000, p.408).

These factors must, however, be conditioned by the influence of a technology's materiality, in that technology will constrain as well as allow certain affordances to use, with conceptual artefacts such as methodologies and techniques allowing a wider range of uses than hard-wired machines. In addition Orlikowski (2000, p.409) states that 'technology is strongly influenced by users' understanding of the properties and functionality. These factors are in turn influenced by the 'images, descriptions, rhetoric's, ideologies and demonstrations presented by intermediaries such as vendors, journalists, consultants, champions, trainers, managers and "power" users' (Orlikowski, 2000, p. 409; Orlikowski et al. 1995).

Orlikowski (2007; 2010) argues that a failure to fully consider the socio-material impact of technology on organisations is a factor of ontological perspective. Both technological determinism and sociotechnical approaches are based on a fundamental 'ontology of separateness', which shares 'a simple dualistic view of agency which claims that agency is located either in the human or in the artefact' (Orlikowski, 2010, p. 134). Over recent decades this perspective has been challenged as a number of scholars (Pickering, 1995; Knorr-Cetina, 1997; Suchman, 2007; Barad, 2003; Latour, 2005) have been considering a ‘relational ontology’, which rejects the notion that the world is composed of ‘individuals and objects with separately attributable properties’ (Orlikowski, 2010, p. 134). This body of work characterised by the term ‘entanglement in practice’ (Orlikowski, 2010, p. 135) will therefore form the basis of the next chapter within this thesis.

2.9 Summary

This chapter has highlighted the role of technological determinism as the dominant paradigm within healthcare, manifesting itself with an on-going desire to adopt and utilise new technologies including manufacturing production systems. Critics of this perspective consider technological determinism to be little more than an enforcement of socio-political control, enacted by powerful actors including medical staff and technology suppliers, together with the increasing expectations of patients. A technological deterministic approach pays little attention to the influence of human agency or free will, nor does it allow for the potential that social groups may change and influence technology over time. The second section of this chapter has considered the social influence of technology from a subjective perspective. The rise of the STS movement has been critically assessed and despite on-going operational problems appears to be a relevant option with which to consider the introduction of technology in a volatile environment such a healthcare.

Ultimately, however, the STS approach is considered to place too much importance on agency at the expense of technologies’ material affordances and constraints. In order to overcome this objective/subjective debate Giddens (1984) structuration theory has been utilised, which posits social structure as a duality encompassing both perspectives. Structuration theory, however, does not explicitly address the issue of technology. In the structurational model of technology Orlikowski (1992) considers technology to be an 'instantiation of some of the rules and resources constituting the structure of organisation'. Technology is thus considered to be a duality, both created by designers operating in a given social context, while at the same time socially constructed by users who may well attach different meanings to individual features. These factors must also be conditioned by considering the influence of an artefact's materiality, which is able to both constrain and offer affordances to use. Finally in order to fully address the impact of materiality on social structure, it is proposed here that we consider the two perspectives not as two distinct entities but as a 'relational ontology' characterised by an 'entanglement in practice' (Orlikowski, 2010, p. 135) and this will form the basis of subsequent chapters within this thesis.

Chapter 3 Sociomateriality

3.0 Introduction

The previous chapter conceptualised the social and material elements of everyday life as distinct entities. Recently this ontological perspective has been challenged by a group of researchers (Pickering, 1995; Knorr-Cetina, 1997; Suchman, 2007; Barad, 2003; Latour, 2005; Mol, 2002; Suchman, 2007) who have been working with a relational ontology that rejects the notion that the world is composed of distinct entities. Instead reality is considered to consist of an intimate relationship between the material and the social, which blurs the distinction between the two. However, within this heterogeneous framework there are many differing theoretical and ontological positions, many of which would not appear to be mutually exclusive. Particularly relevant here is the 'agential realist' perspective developed by Karen Barad (2003) and utilised extensively by Orlikowski (2007; 2010) and Orlikowski and Scott (2008a; 2012). Within the agential realist perspective the social is inextricably linked or 'constitutively entangled' in everyday life (Orlikowski, 2007, p.1437). Other proponents of sociomateriality (Mol, 2002; Pickering, 1995; Leonardi, 2007, 2011) take a less extreme view and maintain the ontological divide between the material and the social. This chapter aims to critically assess our current understanding of sociomateriality. In doing so, it is argued that other theoretical frameworks such as the 'morphogenetic' approach (Archer, 1995) underpinned by 'critical realism' (Bhaskar, 1989) may offer some theoretical and practical advantages over the agential realist perspective. Early criticisms, that the concept of sociomateriality would benefit from a more grounded empirical approach (Styhre, 2011), will be developed to identify clear gaps in the literature, which will form the basis for the empirical research undertaken as part of this thesis.

3.1 Entanglement in Practice

Both technological determinism and the socio-technical approaches are, according to Orlikowski (2010, p.134), based on an 'ontology of separateness', which claim that 'agency is located in either the human or in the artefact'. These factors are clearly illustrated by the following:

> *'as contemporary forms of technology and organising are increasingly understood to be 'multiple, fluid, temporary, interconnected and dispersed' a perspective that renounces the categorical assumption of separateness is likely to offer a more useful conceptual lens with which to think about the temporally emergent sociomaterial realities that form and perform contemporary organisations (Orlikowski, 2010, p.137).*

This relational ontology or 'entanglement in practice' (Orlikowski, 2010, p.135) is beginning to influence research on technology in the management literature for example actor networks (Callon, 1986; Latour, 1992; 2005), sociotechnical ensemble (Bijker, 1995, p.12), mangle of practice (Pickering, 1995), object centred sociality (Knorr-Cetina, 1997, p.9), relational materiality (Law and Urry, 2004), material sociology (Beunza, Hardie and Mackensie, 2006) and multi-dimensional networks (Contractor, Monge and Leonardi, 2011). A shift can therefore be seen in the conventional framing of organisational practices from social, to 'sociomaterial' (Mol, 2002; Suchman; 2007).

According to Suchman (2007, p.260) this shift in conceptual framing requires the following:

> *'a discourse that recognises the deeply mutual constitution of humans and artefacts, and the enacted nature between them'. This does not mean that there are 'no differences between them' only that we 'need to understand the nature of the differences differently' (Suchman, 2007, p.260).*

As highlighted by Introna (2009, p. 25) ‘we are the beings that we are through our entanglements with things, we are thoroughly hybrid beings, cyborgs through and through – we have never been otherwise’.

3.2 Sociomateriality

Although the traditional view of the influence of technology has allowed an insight into the effect on organisational design and structure they have overlooked ways in which ‘organising is bound up with material forms and spaces through which humans act and interact’ (Orlikowski, 2007, p.1435).

The under appreciation of the material aspects of organisational life are summarised by Barad (2003, p.801) below:

> *‘at every turn lately every ‘thing – even materiality is turned into matter of language or some form of cultural representation’. ‘Language matters’. ‘Discourse matters’. ‘Culture matters’. ‘There is an important sense in which the only thing that does not seem to matter anymore is matter’.*

Law and Urry (2004, p.403) argue that current modes of social research do not resonate well with important ‘reality aspects’ of the twenty first century. They list a number of areas where this lack of resonance is particularly pronounced. These issues include the ‘fleeting or ephemeral here today gone tomorrow, the distributed, the multiple, the sensory or the chaotic aspects of modern life’.

More recently a number of researchers (Østerlie, Almklov and Hepsø, 2012; Nyberg, 2009; Johri, 2011) have been challenging these traditional roles by taking an approach that requires us to consider an artefact’s materiality in a way that does not ‘ignore it, take it for granted, or treat it as a special case, and neither does it focus solely on technology effects or primarily on technology use' (Orlikowski, 2007, p.1437).

Within this context the social and the material are inextricably linked or 'constitutively entangled' in everyday life as highlighted below:

> *'Such an alternative view asserts that materiality is integral to organizing, positing that the social and the material are constitutively entangled in everyday life. A position of constitutive entanglement does not privilege either humans or technology (in one-way interactions), nor does it link them through a form of mutual reciprocation (in two-way interactions). Instead, the social and the material are considered to be inextricably related — there is no social that is not also material, and no material that is not also social' (Orlikowski, 2007, 1437).*

> *'entities (whether humans or technologies) have no inherent properties, but acquire form, attributes, and capabilities through their interpenetration. This is a relational ontology that presumes the social and the material are inherently inseparable (Orlikowski and Scott, 2008b, p. 455-456).*

The notion of constitutive entanglement presumes that there are no independently existing entities with inherent characteristics. Humans are thus 'constituted through relations of materiality, bodies, cloths, food, devices, tools, which in turn are produced through human practice' (Orlikowski, 2007, p1438).

Unlike ANT which emphasizes 'the constitutive intertwining and reciprocal inter definition of human and material agency' (Pickering, 1995, p.26) the sociomaterial perspective shifts the 'epistemological and methodological orientation away from tracing ties in networks, towards an examination of performativity and reconfiguration' (Orlikowski and Scott, 2008a, p.25).

Orlikowski (2007, p.1438) states that in particular this requires replacing the idea of materiality as ‘pre-formed substances’ with that of ‘per-formed relations’. Conceptualising organisational practices as sociomaterial allows us to ‘explicitly signify through our language, the constitutive entanglement of the social and material in everyday organisational life’ (Orlikowski, 2007, p.1438).

Orlikowski (2007) highlights the concept of sociomateriality by giving a number of practical examples. The first example assesses the impact of censorship within the Google search engine. The complex algorithm working behind the search engine is considered to ‘configure, in real time, the performance of the emergent sociomaterial assemblage, and thus the everyday practices of researchers seeking information to do their work’ (Orlikowski, 2007, p.1441). In the second example Orlikowski (2007) considers the influence of organisations ‘pushing’ e-mails to colleagues via hand held BlackBerry devices, or the so-called ‘CrackBerrys’ due to their addictive nature. Within this context she concludes that it is not a matter of the Blackberry’s material properties having social impacts, or the new affordances of mobile e-mail devices making communication more efficient. The ‘performativity’ of the BlackBerry is considered sociomaterial, shaped by the particular ‘contingent way in which the BlackBerry service is designed, configured and engaged in practice’ (Orlikowski, 2007, p.1444). The push e-mail capability inscribed in the software has become constitutively entangled with people’s choices to keep the devices turned on, glance at them and to respond or not.

In order to conceptualise this ‘constitutive entanglement’ of the social and material Orlikowski (2007, 2010) utilises the ‘agential realist’ perspective developed by Karen Barad (2003).

3.2.1 Agential Realism

Barad (2003) begins her discussion with a transition from representationalism to performativity. Representationalism can be theorised as a tripartite arrangement, firstly there is ‘the knowledge (i.e. representations)’, on the one hand and the ‘known (i.e. that which is purportedly represented)’ on the other. In addition the existence of the ‘knower’ (i.e. someone who does the reporting) is sometimes made explicit. In this context ‘representations’ become ‘a mediating function between independently existing entities’ (Barad, 2003, p. 804). This ‘taken for granted ontological gap’ generates questions of the accuracy of representations. For example ‘does scientific knowledge accurately represent an independently existing reality?’ ‘Does language accurately represent its referent?’ (Barad, 2007, p. 804)

According to Barad (2003, p. 806) the philosophical issues with the representationalist approach can be traced to the atomic theory of Greek philosopher Democritus; ‘Is the table a solid mass made of wood or an aggregate of discrete entities moving in a void?’ (Barad, 2003, p.806). The ‘Cartesian-cut’ (Barad, 2003, p. 806) identifying a division between the ‘internal’ and ‘external’ is hence brought into question. Barad (2003, p.807) states that ‘there is a requirement to develop coherent philosophical positions that deny that there are representations on the one hand and ontologically separate entities awaiting representation on the other’.

In order to achieve this distinction, Barad (2003, p. 811) proposes taking an ‘agential realist ontology’ defined as a ‘post humanist’ notion of performativity, and one that ‘incorporates important material and discursive, social and scientific, human and non-human, and natural and cultural factors’ (Barad, 2003, p. 808).

In order to conceptualise this relational ontology Barad (2003) draws on the work of Niels Bohr and his Nobel Prize winning quantum model of the atom. Central to this conceptualisation is Bohr's rejection that takes 'things' as ontologically separate entities with, 'inherently determinate boundaries' (Barad, 2003, p. 813). The primary epistemological unit is not considered to be independent objects with inherent boundaries and properties but rather phenomena (Baggott, 1992; McFaddon, 2000). Within this context phenomena are considered to be the inseparability of 'observed object' and 'agencies of observation', resulting in the ontological inseparability of agentially intra-acting components' (Barad, 2003, p.815). The transition from interaction, which presumes a prior existence to intra-action, is considered by Barad (2003, p.815) to constitute a 'profound conceptual shift'.

Barad (2003, p.815) develops the notion of 'apparatus' to refer to the 'specific material discursive practices, which help to constitute phenomena through producing knowledge about them' (Orlikowski, 2010, p. 136). That is 'given a particular method of observing, measuring or examining a phenomena, certain properties of that phenomena will become apparent, whereas others will be specifically excluded'. Specific material configurations of the apparatus constitute an 'agential cut' (in contrast to a Cartesian cut), which 'enacts local resolution within the phenomenon' (Barad, 2003, p.815).

'Phenomena are constitutive of reality. Reality is not composed of things in themselves or things behind phenomena but things in phenomena'. 'The world is a dynamic process of intra-activity in the on-going reconfiguring of locally determinate causal structures with determinate boundaries, properties, meaning and patterns of marks on bodies' (Barad, 2003, p.817).

‘Discursive practices are boundary making practices that have no finality in the on-going dynamics of agential intra-activity’ (Barad, 2003, p.821). Within this context ‘matter is substance in its intra-active becoming – not a thing, but a doing, a congealing of agency. Matter is a stabilising and destabilising process of intra-activity’ (Barad, 2003, p.822). The relationship between the material and the discursive is one of ‘mutual entailment’. ‘Neither is articulated/articulable in the absence of the other matter and meaning are mutually articulated’ (Barad, 2003, p.822). Agential intra-actions are causal enactments where the component parts of the phenomenon one of which “the cause” expresses itself in effecting and marking the other “the effect”. This causal intra-action in a scientific context is termed ‘measurement’ (Barad, 2003, p.824). ‘Intra-actions always entail particular exclusions and exclusions foreclose any possibility of determinism providing a condition for an open future’. Therefore ‘intra-actions are constraining but not determining nor unconstrained freedom’ (Barad, 2003, p.826). This post humanist approach makes evident the importance of taking account of “human”, “non-human” and “cyborgian” forms of agency. This is considered both ‘possible and necessary’ because agency is a matter of ‘changes in the apparatus of bodily production’. Holding the category “human” fixed is therefore considered to ‘exclude an entire range of possibilities in advance’ (Barad, 2003, p.826).

3.2.2 Empirical examples of sociomaterial practice from an agential realist perspective

A practical application of the concept of sociomateriality, utilising an ‘agential realist’ (Barad, 2003) perspective, is provided by Wagner, Newell and Piccoli (2009) and Wagner, Moll and Newell (2011) during their investigation ‘off-the-shelf’ enterprise systems (ES) system within a University setting.

Wagner, Newell and Piccoli (2009, p. 276) state that the main problem with the introduction of 'off-the-shelf' as opposed to custom-built ES, is 'the need to address misalignments between "best practices" in the product and legacy practices within the adopting organisation' (Wagner, Newell and Piccoli, 2009, p.276). This study aimed to explore the 'how, when and where resistance to an ES assemblage is accommodated, through sociomaterial adaptions, in the post- roll out period to enable a troubled project to survive' (Wagner, Newell and Piccoli, 2009, p.277). Adopting a sociomaterial perspective suggests it is important to explore the 'initial design/configuration, who was involved/excluded, and then follow through to examine how the sociomaterial assemblage is reconfigured through a process of negotiation' (Wagner, Moll and Newell, 2011, p.183).

The project began with the aim of introducing an ES accounting system to facilitate the introduction of Time Phased Budgeting (TPB) rather than the traditional Commitment Accounting (CA) system used within a University. However, not long after the introduction of the system problems arose because of an exclusion of the CA functionality. Worried that the new academic year would bring complications, the rhetoric of the project team changed and a negotiated plan of action was agreed. This action plan included 'leaving the legacy CA system until commensurate ES functionality was created; second, to mimic CA practices in the ES environment by customising software; and third, to make organisational changes that would support the transition to an ES-enabled environment' (Wagner, Newell and Piccoli, 2009, p. 282). Although the project was considered a success, these temporary changes were still in operation five years after the implementation.

In order to understand how this project was “turned around” the authors argue that the initial undertaking to impose best practice represented a particular sociomaterial assemblage. The interrelation of things and people are seen as the result of ‘designing material objects to scaffold administrative activity, thereby enabling and constraining particular types of work (how)’ (Wagner, Newell and Piccoli, 2009, p. 284).

During the course of the project however ‘the material objects they designed to scaffold social activity were unable to dictate action’. The sociomaterial assemblage ‘set up the need for adaptions if the system was to be accepted (how)’ (Wagner, Newell and Piccoli, 2009, p. 285).

Early resistance to the system revealed that accommodation through ‘sociomaterial adaptations (how)’ were required at the ‘boundaries between communities, which are disrupted by one field of practice to impose practices on another (where)’ (Wagner, Newell and Piccoli, 2009, p. 285).

Wagner, Newell and Piccoli (2009, p. 286) argue that the different perceptions of the ‘ES success’ illustrates how ‘materiality is only consequential, when human actors draw upon it in practice’ (Wagner, Newell and Piccoli, 2009, p. 286). In conclusion, this group comment that ‘negotiated practice implies that one cannot account on forcing software based best practice on a population. Rather one should come to expect a need to negotiate by re-arranging the sociomaterial elements of a practice’ (Wagner, Newell and Piccoli, 2009, p. 290). This approach to sociomateriality is considered by this group to be different to that of ANT because within ANT while material objects and humans have agency, within sociomateriality agency resides in the assemblage not independently in either the material or the social (Wagner, Newell and Piccoli, 2009, p. 281).

In another empirical example of the sociomaterial perspective drawn from the field of IS development, Doolin and McLeod (2012) contrasts the development of performance based sociomaterial configurations with that of ‘boundary objects’ (Star and Griesemer, 1989; Carlile, 2002; 2004). Within this context, the inherent ‘interpretive flexibility’ of ‘project related artefacts’ acting as boundary objects are considered to facilitate ‘understanding and cooperation across diverse knowledge domains’ (Doolin and McLeod, 2012, p.570).

Star and Griesemer (1989, p.410) originally defined a ‘boundary object’ as ‘an object which lives in multiple social worlds and which has different identities in each’. Accordingly four types of heterogeneous boundary objects were described and are highlighted in Table 4. It must be acknowledged that within this framework the list was by no means considered to be exhaustive.

Table 4 Typology of boundary objects as defined by Star and Griesemer (1989)

Boundary object	Illustrative example
Repositories	Ordered piles of objects indexed in a standard form e.g. a library
Ideal types	Symbolic representations such as an atlas
Coincident boundaries	Common objects which have the same boundaries but different internal contents
Standardised forms	Standard operating procedures

In a subsequent review of the original concept, Star (2010, p.602) redefines boundary objects in terms of 'interpretive flexibility, material and organisational structure and the question of scale and granularity'. A boundary object is thus considered as 'a sort of arrangement that allows different groups to work together without consensus', or 'organic infrastructures' arising from 'information and work requirements as perceived locally and by groups who wish to cooperate' (Star, 2010, p.602).

The dynamic between the material and the organisational structure (deemed to be at the core of the notion of boundary objects) is highlighted below:

- The object resides between social worlds where it is ill structured
- When necessary, the object is worked on by local groups who maintain its vaguer identity as a common object, while making it more specific, more tailored to local use within a social world, and therefore useful for work that is NOT interdisciplinary
- Groups that are cooperating without consensus tack back- and-forth between both forms of the object

Carlile (2002; 2004) utilises the concept of boundary objects to provide a framework for knowledge transfer and innovation in product design. A syntactic approach (i.e. 0s and 1s in the case of computer technologies) is useful when the boundaries are 'unproblematic' and the primary concern is knowledge transfer. The semantic approach acknowledges that even if a common language is present interpretive differences can be problematic. The problem then shifts from processing information to 'translation' (Star and Griesemer, 1989, p. 393) or the creation of 'shared meanings' (Carlile, 2002; 2004). The transition from a semantic to a pragmatic boundary arises when the 'novelty presents results in different interests among actors which have to be resolved'. In this instance 'domain-specific knowledge as well as common knowledge may need to be transformed to effectively share and access knowledge at boundary' (Carlile, 2004, p.559).

Carlile (2002) utilises the syntactic, semantic and pragmatic framework developed above to highlight the characteristics of effective boundary objects as highlighted in Table 5 below:

Table 5. Typology of boundary objects developed by Carlile (2002)

Types of knowledge boundary	Categories of boundary objects	Characteristics of boundary objects
Syntactic	Repositories	Representing
Semantic	Standardised forms and methods	Representing and learning
Pragmatic	Objects, models and maps	Representing learning and transforming

From a syntactic perspective the importance of having a shared language at the boundary is considered fundamental. An effective boundary object at the semantic boundary provides a concrete means for individuals to specify and learn about their differences, in this case illustrated by standardised forms and protocols. At the pragmatic boundary an effective boundary object 'facilitates a process where individuals can jointly transform their knowledge' (Carlile, 2002 p.452). In this instance 'objects, models and maps' are the only category of boundary object that 'directly supports transforming knowledge' (Carlile, 2002, p.452). The capacity of an effective boundary object must then be twofold, both practical in establishing a shared syntax or shared meaning, and political transforming localised shared knowledge into new knowledge capable of overcoming differences. The practical and political capacity of a boundary object at the pragmatic boundary is considered to represent 'the infrastructure or process where current and novel forms of knowledge' can be jointly transformed producing more shared knowledge at the boundary (Carlile, 2002, p.453).

Within a healthcare environment, the transformational potential of boundary objects have been highlighted with the emergence of 'care pathways' defined as 'multi-disciplinary care management tools which map out chronologically key activities in a healthcare process' (Allen, 2009, p.354). The adoption of care pathways as a 'classic' boundary object make 'it highly effective in aligning management, clinical and user interests around healthcare quality agenda' (Allen, 2009, p.360). The transformative power of care pathways can however be seen to 'bring to the surface many of the tensions they are designed to resolve'. Rather than focusing on conformity and standardisation, there is then value in 'accepting variation so that pathways can be tailored for particular purposes and creative solutions' (Allen, 2009, p.360)

With regard to the possibility of humans being able to act as boundary objects Star and Griesemer (1989, p.411) state that marginal people who inhabit more than one social world face an 'analogous situation' and hence share characteristics with boundary objects. The notion that humans can act as boundary objects is ultimately rejected by Star and Griesemer (1989, p.412) on the basis that the strategies employed by marginal people to manage multiple memberships can be volatile, elusive or confusing, which render them unable to have the functionality of a boundary object.

This perspective is however challenged by Zdundczyk (2006) who argues that marginal people by 'virtue of their partial and simultaneous membership of different social worlds should be characterised by the kind of internal heterogeneity, which allows members to view them in different categories, while still retaining a 'common identity across sites' (Star and Griesemer, 1989). Zdundczyk (2006) considers that 'interim managers' and 'management consultants' may display properties of a marginalised individual displaying the qualities of a human boundary object.

Doolin and McLeod (2012) state that although boundary objects can be considered as either abstract or material, the IS literature has tended to focus on the interpretive flexibility of boundary objects and their boundary spanning role across communities rather than their materiality.

Given their common concern with objects, Doolin and McLeod (2012, p.571) consider the concept of sociomateriality and boundary objects to be complementary, as they share a similar ontological perspective. This claim would appear to be supported by Star (2010, p.603) who states the following:

> *'The words "boundary" and "object" may need some explaining, as well. Often, boundary implies something like edge or periphery, as in the boundary of a state or tumour. Here, however, it is used to mean a shared space, where exactly that sense of here and there are confounded. These common objects form boundaries between groups through flexibility and shared structure – they are the stuff of action'*

> *'In common parlance an object is a thing, a material entity composed of more or less well-structured stuff. In the term "boundary object", I use the term object in both its computer science and pragmatist sense, as well as in a material sense. An object is something people (or, in computer science, other objects and programs) act toward and with. Its materiality derives from action, not from a sense of prefabricated stuff or "thing" – ness'.*

Doolin and McLeod (2012) draw upon the theoretical literature of both sociomateriality and boundary objects to describe the development and use of a prototype multi dimensional database. From a boundary object perspective this prototype became a design representation in the local practices of various groups including in-house representatives, external management consultants and software vendors. Materially it was considered an 'object of evaluation' which 'existed in multiple versions and places, and was modified over time as aspects of the solution requirements became known and defined' (Doolin and McLeod, 2012, p.581). Doolin and McLeod (2012, p.573) propose that sociomateriality has five implications for how we understand boundary objects as highlighted in Table 6 below:

Table 6. Application of sociomaterial concepts to the analysis of boundary objects (Doolin and McLeod, 2012, p.582)

Concept	Boundary object feature observed	Sociomaterial explanation
Practice	To become a boundary object in use the prototype needs to be jointly recognisable and meaningfully incorporated into local practices	Not an independent technical object but constituted as a boundary object in the performance of the sociomaterial practices which in turn helped to configure practice
Temporal emergence	Prototype was not static but subject to change during the course of the project	Prototype emerged temporally in practice
Sociomaterial agency	The materiality of the prototype afforded certain aspects of boundary spanning practices and constrained others	The possibilities for knowledge transfer and the translation of meaning between project participants was a factor of the sociomaterial agency produced from the constitutive entanglement of human actor and material agency
Performativity	The prototypes boundary-spanning function and effectiveness varied across time and space	Diverse sociomaterial assemblages incorporating the prototype were performed differently across different occasions, sites and participants producing varying effects
Multiplicity	As a boundary object the prototype was interpretively flexible across the project groups, recognisable by each while satisfying their different informational needs	Rather than a singular boundary object, a multiplicity of boundary objects were performed

3.2.3 Sociomateriality in a Healthcare environment

Within a healthcare environment, sociomaterial considerations have been utilised to investigate organisational changes within a UK NHS Accident & Emergency (A&E) department. Crump and Latham (2012) investigated changing practices following the introduction of General Practitioners (GP) into the A&E team, normally composed of dedicated secondary care consultant staff and other more junior doctors. The traditional working environment within an A&E department is considered to rely on a great deal of routine. This routine is perceived 'as a social and material (Sociomaterial) accomplishment with a central role being played by a set of wooden boxes that act as an information system within the department' (Crump and Latham, 2012, p.52). This group argue that one way in which to explore routine operating in healthcare is to examine the 'differences' that exist within this environment, as 'different healthcare practices may produce different diagnosis for patients' (Crump and Latham, 2012, p.53). This research highlights the introduction of GP colleagues within the department who were initially employed to deal with complex cases, especially in the elderly population who tend to have multiple symptoms. Within this group it was considered that GP staff have a better knowledge of the population and a 'different model of risk' being 'less inclined to admit such patients to hospital' (Crump and Latham, 2012, p.57). Initially at the start of this study the wooden boxes used to facilitate patient triage became and were considered by the group to be the obligatory point of passage also became a source of tension between the GP's and the hospital based consultants. Some of the GP's stuck rigidly to the original brief and 'cherry picked' complex cases within their comfort zone, while others selected or were allocated a mixture of cases. After 12 months however the majority of GP staff would engage with the triage system 'as they began to act like the hospital staff' (Crump and Latham, 2012, p.60). The triage boxes were regarded as part of a network of sociomaterial relations and were considered to play a key role in 'stabilising/making routine these relations' (Crump and Latham, 2012, p.61). Within this research 'negotiation', 'change' and 'compromise' resulted in an 'on-going oscillation between singularity and multiplicity (i.e. the GP role to the role of GP/hospital doctor and back again).

Crinson (2008) has also studied the role of sociomateriality in addressing the 'insider/outsider' security threat to healthcare information systems. This research highlights the impact of UK government reforms, which have encouraged public and private sector partnerships, which entails the crossing (and possibly even fragmentation) of traditional organisational and professional boundaries. Crinson (2008) states that the insider/outsider duality is better conceptualised by adopting a sociomaterial perspective, with its focus on 'how the demands of working with these information systems impact upon and in turn are reconfigured themselves by material practice within an organisation' (Crinson, 2008, p.205). Within this context information systems such as 'choose & book' are considered to be a 'complex and highly unpredictable process that has to be alert to emerging practice' (Crinson, 2008, p.205). One possible solution to these issues is to 'encourage healthcare partners to develop local patient information security configurations that both acknowledge and facilitate professional discretion over the access and use of patient data' (Crinson, 2008, p.206).

3.3 Relational ontologies maintaining the ontological divide

3.3.1 ANT

One of the most influential examples of entanglement in practice, which maintains the ontological divide between the social and material, is that of ANT (Callon 1986, 1991; Latour, 2005; Law 1992).

According to Callon (1986, p.196) ANT or the 'sociology of translation' is based on the following three principles:

> 'agnosticism (impartiality between actors engaged in a controversy), generalised symmetry (the commitment to explain the conflicting viewpoints in the same terms) and free association (the abandonment of all *a priori* distinctions between the natural and the social)'.

ANT is therefore considered to be a 'relational and process oriented sociology that treats agents, organisations and devices as interactive effects' (Law, 1992 p.389). Within ANT the suggestion is that 'the social is nothing other than the patterned networks of heterogeneous materials', in which 'bits and pieces from the social, the technical, the conceptual and the textual are fitted together and converted or translated into products' (Law, 1992, p.380). The fluid and diverse nature of ANT is thus best considered as a form of 'material semiotics' and hence 'it isn't possible to explore the social without at the same time studying the 'how questions of relational materiality' (Law, 2008, p. 142).

ANT views the world as a network of 'interconnections of messages' (words, ideas, objects, graphs spread-sheets etc.)' and hence it is 'the connections that are crucial rather than the things themselves' (Hall, 2005, p.2676). During the process of interconnection between actors these messages or translations are 'inscribed with meaning' (Hall, 2005, p.2676). This 'meaning' is however open to a degree of interpretive flexibility resulting in actors exerting agency through these interconnections in an unpredictable way, 'meanings, actions, objects are precarious and undergo constant change' (Hall, 2005, p.2676).

A key feature of ANT is that human and non-human actors or 'actants' are considered to be symmetric in that each is given equal agency (Doolin and Lowe, 2002; Cresswell, Worth and Sheikh, 2010). Networks are composed 'not only of people, but also machines, animals, texts, money, architectures-any material that you care to mention' (Law, 1992, p.380). Just as people have their preferences in the way they interact, all material artefacts also contribute to the patterning of social order and hence the functioning of the network as a whole (Law, 1992; Cresswell, Worth and Sheikh, 2010; Doolin and Lowe, 2002). The key features of ANT are highlighted in table 7 below:

Table 7 Key concepts in ANT (Walsham, 1997, p. 468)

Concept	Description
Actor (or actant)	Both human and non- human actors such as technological artefacts (Doolin and Lowe, 2002, Cresswell, Worth and Sheikh, 2010, p.2).
Actor-network	Heterogeneous network of aligned interests, including people, organisations and standards (Walsham, 1997, p.48)
Translation	The ways in which heterogeneous actors associate with each other and constitute, order and bring networks to an end (Papadopoulos, Radnor and Merali, 2011, p. 172)
Problemisation (Or how to become indispensible) (Callon 1986)	When an actor makes an effort to make other actors subscribe to its own conceptions by demonstrating that he/she has the right solutions to the problem (Papadopoulos, Radnor and Merali, 2011, p. 172)
Interessement (Or how allies are locked into place) (Callon 1986)	The group of actions by which an entity attempts to impose and stabilize the identity of the other actors it defines through its problemisation. Methods include 'simple force' seduction or solicitation' (Callon, 1986)
Enrolment	The process by which the focal actor creates a body of allies, human and non-human, through a process of translating their interests to be aligned with the actor-network (Walsham, 1997, p.48)
Mobilisation	Solutions suggested by the focal actor become accepted and 'black boxed' (Kaghan and Bowker, 2001, p. 258) as investment in the network means that withdrawal would be unlikely.
Obligatory Passage Point	Sets a number of specific conventions, rules, assumptions and ways of operating that have to be followed by actors who wish to follow the first actor (Papadopoulos, Radnor and Merali, 2011, p. 172)
Inscription	The creation of artefacts to ensure the interests of the actor-network are protected and the roles of actors are recorded (Papadopoulos, Radnor and Merali, 2011, p. 172)

According to ANT although all phenomena are 'the effect of the product of a heterogeneous network, in practice humans cannot cope with endless network ramifications' (Prout, 1996, p. 202) and will treat a network as a 'single block' (Prout, 1996, p. 202) or 'punctualisation' (Law, 1992, p. 385). Social life, as we know it, would be impossible unless these 'network packages' are considered to have 'relative stability and durability' (Prout, 1996, p. 202).

On some occasions networks do become visible and this occurs primarily when they fail (Law, 1992; Prout, 1996; p.201). Thus for a healthy person most of the workings of the body are hidden from them. By contrast 'for someone who is ill and even more so for the physician, the body is converted to a complex network of processes, and a set of human technical and pharmaceutical interventions' (Law, 1992, p. 385).

The actor network is then realised by engaging or 'enrolling' human and non-human participants into an emerging network through a process of 'negotiation and translation' (McLean and Hassard, 2004, p.494). Although no 'social or natural actor wholly directs the process' some 'social actors attempt to manage the network to achieve a particular outcome' (Hall, 2005, p.2676). Through the process of 'problemisation' the focal actor, possessing a potential solution to a problem, will be required to 'formulate the problem so that the latter perceives the former as indispensible for the solution of the problem' (Hall, 2005, p.2676).

Interessement follows problemisation, as an attempt is made to 'impose the identities and role identified in problemisation', so that 'any already established networks are replaced by the new network' (Papadopoulos, Radnor and Merali, 2011, p. 173).

The 'enrolment' of actors as constitutive elements of that network involves the establishment of an 'obligatory passage point' (OPP), which entails setting conventions, rules, assumptions and ways of acting that have to be followed by constituent members' (Papadopoulos and Merali, 2008, p.42). This is considered an important element in articulating 'conscious commitment of actors to specific networks' with associated 'explicit and visible conditions for coherence within the network' (Papadopoulos and Merali, 2008, p.42).

The final stage of the process occurs when all of the actors in the network are 'mobilised' to behave as a coherent entity where the 'identities of the individual actors are no longer discernable' (Papadopoulos and Merali, 2008, p.42). Mobilisation results in their actions becoming 'black boxed' (Kaghan and Bowker, 2001, p. 258) and 'collectively constituting the actor-network' (Papadopoulos and Merali, 2008, p.42). The core of ANT as described can then be summarised as follows:

> *'a concern with how actors and organisations mobilise, juxtapose and hold together bits and pieces out of which they are composed; how they are sometimes able to prevent these bits and pieces from following their own inclinations and making off; and how they manage, as a result, to conceal for a time the process of translation itself and so turn a network from a heterogeneous set of bits and pieces each with its own inclinations, into something that passes as a punctualised actor' (Law, 1992, p.386).*

Within this context a technological artefact can be considered as 'packaging a network and extending it through time and space' (Prout, 1996, p.202) or the so-called 'immutable mobile' (Latour, 2005). In doing so it can 'delegate' a network (Latour, 1991, p.261) 'standing in for it, repeating it and performing its work in times and places remote from its origin' (Prout, 1996, p.202). Within ANT these device packages are considered to involve translations by which entities ‘mutually enrol’ each other. In doing so they claim to speak for, interpret, configure and re-configure each other (Prout, 1996, p.202).

Prout (1996, p.202) conceptually summarises the interaction of technology and humans as follows:

> *‘As different human actors interact with a device the alliances they form become contested, precarious, shifting and treacherous. A device is never simply inserted or diffused into a setting but is always subject to these processes of translation during which humans interact with it, each configuring and reconfiguring each other in unpredictable and unexpected ways. Tracing these processes of translation is therefore, an analytical task of actor-network studies that parallel the unpicking of punctualisation’.*

Law (1992, p.389) states that ANT allows us to ‘explore social effects whatever their material form allowing us to answer the ‘how questions’ about ‘structure, power and organisations’. According to Latour (1991, p.103) ‘a full description of power and domination can only be obtained by reconstructing networks’. A consideration of power relationships is particularly relevant in the ‘fast moving and ever changing area of healthcare’, especially with regard to ‘government led change initiatives and reforms’ (Creswell, Worth and Sheikh, 2010, p.3). Particularly relevant here are the recent healthcare reforms introduced by the UK NHS government following the publication of the white paper ‘Equity and Excellence: Liberating the NHS’ (Great Britain. Department of Health, 2010c; 2010d).

According to Hanseth, Aanestad and Berg (2004, p.118) the network, constituting a technological artefact, includes its designers and their social context’. When an artefact is used within an organisation ‘some elements of this network are removed and others included, some elements are included in both cases, but they are also changing because they are parts of a different network’ (Hanseth, Aanestad and Berg, 2004, p.118).

Cresswell, Worth and Sheikh (2010) conclude that ANT's 'focus on fluidity also means that it acknowledges that reality is not predictable and the multiple realities can co-exist, with reality being effectively performed in different contexts and by different actors'. As modern technologies increasingly involve 'novel virtual spatio-temporal configurations', which come to 'define our existence' ANT can 'potentially offer new and meaningful ways of representing the associated processes and practices' (McLean and Hassard, 2004, p.516).

ANT has been used to examine a wide range of organisational issues including strategic management (Steen, 2010), quality improvement in healthcare (Broer, Neiboer and Bal, 2010) communication technology (Andrade and Urquhart, 2009) Information Systems including healthcare accounting (Bloomfield, Coombs, Cooper and Rea, 1992; Bloomfield and Vurdubakis, 1994), and the 'geneticisation' of heart disease (Hall, 2005).

Specifically, within a health care environment, Berg (1999a; 1999b; 2001) utilises the framework of ANT to explore the development of the EPR and its impact on shaping the social relationships between healthcare professionals.

According to Berg and Bower (1997, p.513) 'the modern patient's body' is produced through 'embodied, materially heterogeneous work'. Artefacts such as 'urine containers, infusion pumps, nursing routines, doctors consultations and the medical record are considered intermediaries which 'constitute a network within which the body acquires its specific ontology' (Berg and Bower, 1997, p.514). As a consequence 'without nurses, record systems or the stethoscope, the medical doctor as we know it would not exist' (Berg, 1999a, p. 89). Within this context it is vital to understand the 'generative' properties of such technologies in a 'relational way, without exclusively attributing this activity to either the tool itself or the human working with it' (Berg, 1999b, p.373). A relational ontology is considered imperative if we want to develop 'new competencies for personnel or to facilitate cooperation over time, space, boundaries and cultures' (Berg, 1999b, p.374). A relational perspective is also considered the starting point to understand the politics of IT. Only through an understanding of the intricate interrelation of human worker and tool can we re-write the traditional 'deskilling' or 'empowering' accounts of formal technologies (Berg, 1999b, p.374).

More recently ANT has been utilised to explore the introduction of Lean projects in an NHS environment, in this case the Pathology and Day Case units, (theatres, endoscopy and A&E) (Papadopoulos and Merali, 2008; Papadopoulos, Radnor and Merali, 2011).

The Pathology problems mirrored problems identified during this research included 'delayed turnaround times' created by 'uneven demand for service', 'delays caused by late deliveries', coupled with inadequate staffing levels and poor organisation within the specimen reception area (Papadopoulos and Merali, 2008, p. 44). Early attempts at 'problemisation' were not well received as staff felt the initiative was just another 'management fad' (Papadopoulos, Radnor and Merali, 2011, p. 179).

Despite this initial dip in enthusiasm or a failure to fully 'mobilise' staff the appointment of a new Chief Executive Officer (CEO) together with the promise of further investment in technology began to turn the project around from a failure to a success. The new CEO's presence was seen as a means to 'persuade staff to embrace, understand and accept – be translated into Lean' (Papadopoulos, Radnor and Merali, 2011, p.179). Opposing staff began to realise the importance of the tangible benefits of the project and the resources they would receive and were subsequently translated into Lean.

3.4 Criticisms of ANT

The first observation is that ANT is not 'a unified body of knowledge' (Walsham, 1997, p. 468) as its developers frequently modify elements of the theory. ANT can be viewed as both a theory and a methodology providing 'theoretical concepts as a way of viewing elements of the real world which need to be traced by empirical work' (Walsham, 1997, p. 469) In practical terms the use of ANT varies from full- scale applications, which are relatively rare to more selective use of the key tenets (Walsham, 1997).

3.4.1 Problems of generalised symmetry

A major criticism of ANT is that it centres on the symmetrical treatment of humans and non-humans, which Collins and Yearly (1992) consider ANT to be an 'abdication of human responsibility' (Walsham, 1991 p. 469). Within this context, proponents of ANT are also criticised for providing essentially human centred accounts. A related issue highlighted by McLean and Hassard (2004, p. 506) is the 'relative positioning, which appears to provide non-humans with a higher status in their relation to humans'.

3.4.2 Problems of description

According to Walsham (1997, p.476), another methodological problem relates to studies that follow the methodological guidelines of ANT results in the production of a 'book-length output'. Cresswell, Worth and Sheikh (2010, p.8) note that 'the challenge for researchers, dealing with multiplicities and a fluid reality, is to achieve a balance between the focus of the investigation and the acknowledgment that multiple different realities can exist without letting these differences mask the complexity of the relationships'. McLean and Hassard (2004, p.499) concur with these comments stating that the 'inclusion/exclusion debate is essentially a question of where to cut the network'.

3.4.3 An amoral stance

Another major criticism of ANT is that it 'fails to examine in detail the political and moral issues underlying the technologies they study' (McClean and Hassard, 2004, p.508). In particular Winner (1993, p.369) highlights that the identification of 'relevant social actors' potentially undermines those groups who are 'constantly excluded from power', and as a result 'potentially important choices are never surfaced or debated' (Winner, 1993, p.369).

Responding to the criticism of immorality, apoliticism or moral relativism Latour (1991, p.130) states that 'refusing to explain closure of a controversy by its consequence does not mean that we are indifferent to the possibility of judgement, but only that we refuse to accept judgements that transcend the situation'. Latour (1991, p.130) goes on to state that efficiency; truth, profitability and interest are simply properties of networks, not statements. Domination is an effect not a cause'.

One example of ANT research engaging explicitly with the political and moral issues is provided by Star (1991, p.43) in which she uses the example of her own allergy to onions and the indifference of outlets in the McDonalds food chain to address the issue, as highlighted below:

‘a stabilised network is only stable for some, and for those who are members of a community of practice who form/use/maintain it. And part of the public stability of a standardised network often involves the private suffering of those who are not standard- who must use the standard network, but who are also non-members of the community of practice’.

3.4.4 Persistence of a network over space and time

Another concern with regard to ANT, highlighted by Brooks, Atkinson and Wainwright (2008, p. 455) is that ANT in its original form cannot account for how ‘a network persists over space and time other than at the behest of the focal actor’. The focal actor is considered to have to ‘constantly drive the network’ to exercise ‘their will to translate more actors into the network until it becomes increasingly consolidated and undifferentiated’ (Brooks, Atkinson and Wainwright, 2008, p. 455). The authors argue that a melding of ANT and structuration theory (‘StructurANTion’) has the potential to account for how ‘humanchine’ networks (Brooks, Atkinson and Wainwright, 2008, p. 455) can be reflexively created. An illustration of this process, with regard to clinical audit, is described later in this chapter.

3.4.5 Limited analysis of social structures (micro/macro debate)

According to Walsham (1997, p. 472) ‘actor-network theory addresses the local and contingent, but plays little attention to broader social structures which influence the local’. Walsham (1997, p.472) illustrates this criticism by referencing a citation from Reed (1995, p.332):

‘the theory (ANT) concentrates on how things get done to the virtual exclusion of the various ways in which institutionalised structures shape and modify process of social interaction and the socio-material practices through which it is accomplished’

The micro/macro debate is challenged by Latour (1991, p.118) who states that 'the macro-structure of society is made of the same stuff as the microstructure, especially in the case of innovations, which originate in a garage and end up in a world that includes all garages'. Latour (1991, p.118) concludes that 'the scale change from the micro to macro and macro to micro is exactly what we should be able to document'.

Walsham (1997, p.473) states that he shares some of the concerns expressed in the above debate. He suggests that one way in which these deficiencies maybe overcome 'is to combine the methodological approach of ANT with insights and analyses drawn from theories of social structure'. Walsham (1997) also states that a major criticism of Giddens (1984) structuration theory is that 'the material world of technology is not treated in any depth' (Walsham, 1997, p. 473). The deficiencies of both theories could then be potentially overcome by a combination of structuration theory with the 'methodology and concepts of ANT that would offer more than either one' (Walsham, 1997, p.473). McClean and Hassard (2004, p.507) disagree with this point and state that 'the agency/structure dichotomy is 'antithetical for those adopting an ANT position', 'to talk of structure in the same breath as ANT is to confound the approach'. For these reasons the combination of structuration theory and ANT is deemed 'unfeasible, unbeneficial and undesirable' (McClean and Hassard, 2004, p.508).

Conversely Jones and Karsten (2008, p.127) consider the development of hybrid approaches to 'show a more active engagement with theory, exploring and challenging its limits'. Examples of such a hybrid approach include the combination of ANT with soft systems methodology (Atkinson, 2000) and structuration theory (Brooks, Atkinson and Wainwright, 2008; Greenhalgh and Stones, 2010).

Brooks, Atkinson and Wainwright, (2008), for example investigate the influence of the EPR and IS on the development of clinical audit within the UK NHS. This research highlights that although the patient is considered the object of the audit he/she is not put 'actively at the centre of the process' (Brooks, Atkinson and Wainwright, 2008, p. 453). In this example, it is initially the clinician who 'initiates the audit, undertakes it and uses its outcomes to further their clinical practice' (Brooks, Atkinson and Wainwright, 2008, p. 453). In essence, the clinician's reaffirm their position as 'the most powerful class of actors within the medical health system', while at the same time 'evoking structures of domination' and 'legitimisation' (Brooks, Atkinson and Wainwright, 2008, p. 458).

Building upon a cumulative programme of research (Atkinson and Brooks, 2003; Atkinson and Brooks, 2005; Waring and Wainwright, 2000; Waring and Wainwright, 2002) this framework termed 'StructurANTion' has been developed as 'a tool for Information System research in order to explore its potential impact on the process of reflexivity and emancipatory clinical practice' (Brooks, Atkinson and Wainwright, 2008, p. 454).

Clinical audit is viewed here 'as a formalised and overt form of reflexivity (surfacing and addressing issues) which has served to entrench the clinician and their interests at the centre of healthcare delivery networks along with their clinico-centric 'structured order' within care settings' (Brooks, Atkinson and Wainwright, 2008, p. 456). While it may improve clinical care within this context, clinical audit does not 'mobilise' the emancipatory structure to ‘problemise’ and ‘translate’ the healthcare humanchine network’s incumbent structured order’ (Brooks, Atkinson and Wainwright, 2008, p. 456).

The ‘emancipatory’ feature of this work aims to explore ‘an alternative form of healthcare reflexivity: patient centred audit, in which patients have a more central role, leading to better outcomes’ (Brooks, Atkinson and Wainwright, 2008, p. 456). These changes aim to reconfigure the power relationships in the network in terms of conducting the audit, and in affecting change in the network both of which have the patient as the focal actor’ (Brooks, Atkinson and Wainwright, 2008, p. 458). In conclusion, Brooks, Atkinson and Wainwright, (2008, p.459) state that a number of important lessons were learnt from this process. Firstly ‘clinical audits can benefit from involving healthcare professionals and patients’. Secondly patients may ‘disclose more about their experiences to other patients than to healthcare professionals’. The development of this hybrid theory has then extended the theoretical concepts and practical application of both structuration theory and ANT, within a ‘sensitive professionally driven environment, dominated by clinico-centric power structures.

3.5 ‘ANT and after’

Law and Singleton (2005, p.331) state that traditional social science methods are ‘ill adapted for the study of complex and messy objects’ such as alcoholic liver disease (ALD). In order to overcome these deficiencies Law and Singleton (2005, p.334) suggest that an ontological shift is required which moves away from considering ‘multiple interpretations’ of objects to thinking about ‘multiple objects themselves’. From a performative perspective realities are considered to be ‘enacted into being’ and such enactments take place in the practice of getting to know those realities. ALD is thus described as a messy object because our ‘methods are not geared up to detect or know it’ (Law and Singleton, 2005, p.334).

Working within the framework of ‘ANT and after’ Law and Singleton (2005, p.335) go onto to illustrate three versions of the object ALD, objects as ‘regions or volumes’, ‘networks’ and ‘fluids’ before highlighting a fourth perspective objects as ‘fire’.

3.5.1 Objects as volumes and networks

Initially within this context, objects are considered to occupy a volume in ‘Euclidean space’ and this pathway is explored by reference to Latour’s (1991) concept of ‘immutable mobiles’, something that holds its shape both in a physical and relational context, which can be imagined as a more or less stable network of associations. However according to Law and Singleton (2005, p.336) ‘many (probably all) objects putatively located in physical space can be detected only in a network of relations’. As a result it is ‘not possible to point to a diseased liver without intervening in, or being embedded in, a network of practice for example in a post mortem, ultra sound scan or consultation in a GP practice’ (Law and Singleton, 2005, p.336).

3.5.2 Fluid Objects

In treating objects as fluid Law and Singleton (2005, p.337) go on to explore some of the criticisms of early ANT approach, concerned with ‘invisible work’ and ‘immutability’. In particular it is suggested that although ANT accepts that it takes effort to maintain a network in practice, it ignores the ‘invisible work’ that maintains stability within a network (Law and Singleton, 2005, p.337). The second objection relates to the first in that within early examples of ANT the definition of an object was too rigid and failed to take account of objects which can be understood as being capable of modification analogous to a 'fluid' (Law and Singleton, 2005, p.338; Mol and Law, 1994; de Laet and Mol, 2000). Within this context de Laet and Mol (2000) describe the development and subsequent modification of a hand water pump defined by Law and Singleton (2005, p.339) as a 'mutable mobile' object which may be understood as a set of relations that 'gradually shifts and adapts itself rather than holds itself rigid'. Hence in this context with regard to ALD we are dealing with 'a phenomenon filled with, and made in, invisible and more or less fluid relations' as we move between different names, for example, 'alcoholic liver disease, alcoholic cirrhosis, alcoholic hepatitis or alcoholism' (Law and Singleton, 2005, p.339).

3.5.3 Fire objects

Law and Singleton (2005, p.341) go on to address another concern within ANT that of the 'problem of difference' by focusing on research undertaken by Mol (2002) investigating the 'reality' of atherosclerosis. Law and Singleton (2005, p.342) begin their argument by highlighting that as in Mol's (2002) study different healthcare practices may reveal a different diagnosis, depending on the techniques used to explore the nature of the disease. 'What appears to be an obstruction in a blood vessel after radiographic investigation may not be discovered and corroborated in subsequent ultra sound measurements' (Law and Singleton, 2005, p.341). Difference is then considered to be 'the lot of healthcare professionals: faced with a patient who is suffering, they have to sort out what to make of any differences' (Law and Singleton, 2005, p.342).

Law and Singleton (2005, p.342) state that typically the problem of difference is conceived as a matter of perspective. From this epistemological viewpoint, ALD would be seen as a boundary object as mentioned above. Mol (2002; 2006) however takes another perspective and recommends that objects be viewed ontologically. This means that 'difference is no longer a matter of perspective on a single object but an enactment of different objects in different sets of relations and contexts of practice' (Law and Singleton, 2005, p.342).

According to Mol (2002, p.5):

> *'It is possible to refrain from understanding objects as the central points of focus of different peoples perspectives. It is possible instead to understand them as things manipulated in practices. If we do this – if instead of bracketing the practice in which realities are handled we foreground them – this has far reaching effects. Reality multiples. If practices are foreground there is no longer a single passive object in the middle waiting to be seen from the point of view of seemingly endless series of perspectives. Instead, objects come into being - and disappear – with the practices in which they are manipulated'.*

Atherosclerosis is then not a single object but multiple objects, which come into being in practice.

Such objects are not the gentle flows, discussed above but in this context they take the form of 'jumps and discontinuities', they are energetic, entities or processes that juxtapose, distinguish, make and transform absences and presences'. Hence, within this context, these entities are considered to be 'fire objects' which are 'energetic and transformative', dependent on differences (absent) fuel, (present) flame, dependent on 'otherness' (Law and Singleton, 2005, p.344).

Law and Singleton (2005, p.346) go on to define 'three versions' of ALD, three 'fire objects' each made in 'a series of absences' and crucially 'each made differently'. In a hospital environment it is a 'lethal condition' that 'implies abstinence'. In a substance abuse centre it is a problem that implies regulation and control. In the GP surgery it is a reality that is better than hard drugs' Law and Singleton (2005, p.346). It is a 'multiple disease' (Law and Singleton, 2005 p.348). As such this suggests a requirement for ‘methodological humility’, ‘if the world is messy we cannot know it by insisting it is clear’ (Law and Singleton, 2005, p.350).

3.6 The ‘Mangle of Practice’ (Pickering, 1993; 1995)

This performative, practice based perspective, is also adopted by Pickering (1993; 1995), and Pickering and Guzik (2008), during their investigations into the understanding of the development of scientific knowledge.

Although Pickering (1995) acknowledges a debt to ANT, the development of the ‘mangle of practice’ is seen to overcome some of the criticisms of the former theory, namely a lack of appreciation of time and concerns over the concept of generalised symmetry.

In the development of new machines, material agency is considered to be ‘temporally emergent in practice’. As the outcomes of material agency cannot be decisively predicted in advance, humans must continually explore them in their work. At a minimum this involves ‘delicate material positioning’ or ‘tuning’, where “tuning” is used in the sense of tuning a radio or car engine.

The second concern with ANT, highlighted by Pickering (1995, p.15) revolves around the semiotic ‘interchangeability’ between the human and material realms. Although Pickering (1995, p.15) disputes the ANT concept that there is no difference between human and nonhuman agency, the development of the ‘mangle of practice’ (Pickering, 1995) draws two important conclusions from a consideration of extended symmetry.

The first is that there exist important parallels between human and material agency, with regard to their repetitive quality and emergent nature. Just as machines such as computers are considered to display the same properties day after day, so too are the humans that engage with them. By employing 'standardised gestures and manipulations' when humans engage with machines they act like machines. Although not considered interchangeable the human/machine relationship is considered to involve a high degree of symmetry and interconnection. Secondly the concept of 'tuning' is considered to work both ways on humans as well as non-humans, both human and material agency are considered to be temporally emergent. While the human and material agents cannot be substituted for one another, they are intimately connected or 'constitutively intertwined' (Pickering, 1995, p.17).

As well as identifying parallels between material and human agency Pickering (1995, p.17) also identifies areas where the symmetry between the human and the material appear to break down. Human agency would then appear to involve a degree of 'intentionality' in the sense that scientific practice is organised around specific plans and goals, which have no counterpart in the material world. Within this context the origins of these plans and goals are considered to arise via the modelling of 'existing cultural predispositions' or 'imaginatively transformed versions of its present' (Pickering, 1995, p.19). Modelling is however considered to be an open-ended process with 'no determinate destination' in which an 'indefinite number of future variants can be constructed' (Pickering, 1995, p.19).

In the construction of the 'mangle of practice', Pickering (1995, p.21) argues that through performances 'the doings of human and material agency come to the fore'. Human agents are then considered to be 'agents in a field of material agency in which they struggle to capture machines' as illustrated below:

> *'human and material agency are reciprocally and emergently intertwined in this struggle. Their contours emerge in the temporality of practice, and are definitional of and sustain one another. Existing culture constitutes the surface of emergence for the intentional structure of scientific practice and such practices consists in the reciprocal tuning of human and material agency, tuning that can itself reconfigure human interactions'* (Pickering, 1995, p.21).

The result of this reciprocal interaction can on occasion result in the 'reconfiguration and extension of scientific culture – the construction and interactive stabilisation of new machines and disciplined human performances and relations that accompany them' (Pickering, 1995, p.21).

The concept of "tuning" as developed by Pickering (1995, p.21) involves what he terms the 'dance of agency' whereby the development of a new machine involves the tentative creation of a piece of technology.

The creator then adopts a passive role whilst monitoring of the equipment occurs to see what 'material agency it might effect' (Pickering, 1995, p.21). Symmetrically this period of human passivity is the period when material agency actively manifests itself. If the machine does not perform as intended a second stage of human agency is evoked to 'revise the modelling vectors' (Pickering, 1995, p.22) and the cycle begins again. The 'dance of agency' is thus considered to be a 'dialectic of resistance and accommodation' where resistance denotes 'a failure to achieve and intended capture of agency in practice', and accommodation 'an active human strategy of response to resistance' (Pickering, 1995, p.22). This accommodation can take the form of 'a revision of goals and intentions', changes to the 'material form of the machine, or to the human frame of gestures and social relations that surround it'

(Pickering, 1995, p.22). This performative 'dialectic of resistance and accommodation' is what Pickering (1995, p.23) terms the 'mangle of practice'.

When faced with a technology that affords or constrains action, humans are then faced with two potential alternatives to either change some aspect of their environment or modify the technology itself. Research suggests that in order to achieve their goals humans preferentially change some aspect of their organisational 'routines' or patterns of social action (Pentland and Rueter, 1994; Zack and McKenney, 1995).

3.7 'Imbrication' (Leonardi, 2011)

Leonardi (2011, p.149) suggests that 'studying contexts in which people can choose whether they will change routines or technologies, puts into relief that human and material agencies are the shared building blocks of routines and technologies'. Rather than consider the social and material to be ontologically 'inseparable' (Barad, 2003, p. 81), this perspective suggests that both human and material agencies are 'distinct phenomena neither of which individually are empirically important' (Leonardi, 2011, p.149). It is only when the social and the material become 'imbricated' or 'interlocked' in a 'particular sequence that they together produce, sustain, or change either routines or technologies' (Leonardi, 2011, p.149). The adoption of the 'imbrication' metaphor originally suggested by authors such as Taylor (2001) and Ciborra (2006) is derived from the names used for roof tiles used in ancient Roman and Greek architecture. In this context, it is used to illustrate the 'multiple overlapping and convergence between two streams of representations' (Ciborra, 2006, p.1339) so that they function independently.

In order to convey the concept of imbrication, as a means of illustrating how sociomaterial interactions arise and are maintained over time, Leonardi (2011) like Pickering (1995) utilises the theory of affordances (Gibson, 1986; Stoffregen, 2002; Turvey, 1992; Chemero, 2003). In Gibson's (1986) formulation of affordances Leonardi (2011, p.153) argues that 'people do not interact with an object prior to or without perceiving what the object is good for'.

By contrast, Norman (1999, p.39) argues that and 'perceived affordances' are purposefully build into technology by designers to suggest how a technology should be used. Alternatively, Hutchby (2001) seeks a middle ground between the two perspectives suggesting that affordances are not exclusively the properties of either the human or the material. According to Leonardi (2011, p.153) utilising this formulation, 'materiality exists independent of people, but affordances and constraints do not'. The affordances of an artefact are then considered to 'change across different contexts, even though its materiality does not', as highlighted below:

> *'The affordances of an artefact are not things which impose themselves upon humans' actions with, around, or via the artefact. But they do set limits on what is possible to do with, around, or via the artefact. By the same token, there is not one but a variety of ways of responding to the range of affordances for action and interaction that a technology presents' (Hutchby, 2001, p.453)*

Leonardi (2011) subsequently utilises the imbrication metaphor to investigate the material affordance and constraints of a technology designed to automate computer simulations for crashworthiness engineering works. Leonardi (2011, p.164) states the imbrication metaphor may be helpful in 'specifying why people who can choose to change either their work routines or their technology to better execute their work make the choices they do'. Within this framework it is however acknowledge that although material agencies help people make choices in the way they manage their routines, they are also constrained by its material features. As noted by Pentland and Feldman (2008, p.243) ‘no amount of translation will turn a toaster into a cell phone’.

In contrast to existing approaches which considers material agency as a potential threat to human agency, Leonardi (2011, p.164) considers that the ‘imbrication lens views material agency more neutrally: its influence as either an affordance or constraint depends on the perceptions people construct about it’.

3.8 Concerns on the sociomaterial approach

Although the concept of sociomateriality is considered to be in its infancy, two distinct ontological perspectives can be seen to emerge from the literature. The first stream of research follows Orlikowski’s concept of a relational ontology (Orlikowski and Scott, 2008a; Nyberg, 2009) where the human and the social are constitutively entangled, and hence ontologically inseparable. The second stream of research maintains the duality of the social and the material and focuses on the interaction between the two, conceptualised by authors such as (Pickering, 1995) as a ‘mangle of practice’ or via use of the ‘imbrication’ metaphor proposed by Leonardi (2011).

More recently the notion of sociomateriality, particularly with regard to the agential realist perspective, has been criticised in the literature on both theoretical and practical grounds (Faulkner and Runde, 2012; Mutch, 2013; Leonardi, 2013; Kautz and Jensen, 2013).

From a linguistic perspective, the concept of sociomateriality has also been criticised for introducing yet more ‘jargon monoxide’ into the academic literature as highlighted below by Sutton (2010)

> *‘It is completely beyond me why this word* (sociomateriality) *had to be invented (or perhaps imported from someplace else) and, frankly, I refuse to read the article because using such language is just absurd and deserves criticism’. ‘To return to the sociomateriality article it appears to be on an important subject, but I hope the authors can find a simple word or two to explain what it means to normal human beings’ (Sutton, 2010)*

Kautz and Jensen (2013, p.24) suggest that the differences in ontological perspective adopted by researchers may be partly explained by the environments in which their research take place. For example Orlikowski (2007) utilises the agential realist perspective to investigate the influence of information technologies in situated use e.g. the Google search engine algorithm. In contrast Leonardi (2011) concentrates on crash test simulation within the car manufacturing industry, ‘where things are built from constitutive parts’ (Kautz and Jensen, 2013, p.24).

Kautz and Jensen (2013, p.24) highlights the following concerns:

> *‘the two perspectives are in contradiction to each other and the question is asked can sociomateriality be a concept with two different ontologies; one of inseparability and the other separability, the confusion about what is ‘sociomaterial imbrication’ (Introna and Hayes, 2011, p.107) – the separability of inseparability becomes even greater’.*

An opponent of the agential realist sociomaterial approach is Alistair Mutch (2013, p.28) who describes the notion of sociomateriality as an ‘umbrella’ term, covering a wide variety of approaches to the relationship between the social and the material’. Mutch (2013, p.28) argues that a concept based on the ‘agential realist’ approach proposed by Barad (2003) neglects, the ‘specificity of the systems involved’ and is unable to deal ‘adequately with the broader context of practice’.

In order to overcome these shortfalls Mutch (2013) proposes that the social realism of Margaret Archer (1995), which has its roots in the development of critical realism by Roy Bhasker (Collier, 1994), is a suitable alternative to the ‘agential realism’ of Barad (2003). A critical realist approach is considered to offer ‘more resources for the consideration of the important role of the material in contemporary organising than sociomateriality’, which is argued to be taking a ‘wrong turn’ (Mutch, 2013).

Mutch (2013) highlights three primary concerns with regard to the development of the concept of sociomateriality to which Leonardi (2013) responds and develops in great detail within the same publication.

3.8.1 Lack of unique explanatory power

The first problem, identified by Mutch (2013, p.28), casts doubt on the potential lack of unique explanatory power of the notion of ‘strong sociomateriality’ based on the ‘agential realist’ perspective of Barad (2003). Accordingly Mutch (2013, p.30) argues that ‘it is not easy to see how this is used to generate insights that would not be gained from other approaches’ such as socio-technical systems and actor network theory, without such ‘dense philosophical ideas’ (Leonardi, 2013, p.66).

In support of the sociomaterial perspective Kautz and Jensen (2013, p.25) conclude the following:

> *'some might argue that approaches already exist to provide a solution towards the intertwining of humans and technology in practice such as systems thinking (Checkland and Scholes, 1990) sociotechnical systems (Mumford 2006) and actor network theory (Latour 1991, 2005). However others may argue that all of these approaches have shortfalls and non are as clear about a relational ontology and an ontology of inseparability, none is as clear about the phenomenon, practices rather than objects, thing or entity as a primary ontological unit of analysis as it is suggested in the notion of sociomateriality'.*

The concept of sociomateriality is then suggested as a 'new approach and not academic jargon monoxide after all, or is it?'

Robey, Raymond and Anderson (2012, p.225) offer a potential solution to the problem by suggesting that the revision of existing theories, that nominally address or marginalise material features, may be a useful strategy. Highlighted examples of this middle ground strategy within the IS literature are provided by Adaptive Structuration Theory (Markus and Silver, 2008) and Organisational Routines Theory (D'Adderio's, 2008, 2011).

Mutch (1999, p.479) suggests that critical realism, in the form of Archer's (1995) 'morphogenetic approach', provides a stronger framework than structuration theory particularly with the inclusion of the concept of 'inscription' and 'irreversibility'.

3.8.2 Inability to perform empirical studies

Secondly Mutch (2013, p.31) argues that the rejection of the social material duality, at the heart of Barad's (2003) 'agential realist' philosophy, creates difficulties developing 'appropriate language to express very complex ideas'.

In order to illustrate this point Mutch (2013, p.31) cites the difficulties identified by Wagner, Newell and Piccoli (2010, p.292-293) in adopting a sociomaterial perspective during the implementation of an enterprise resource planning system as highlighted below:

> *'The on-going challenge for researchers attempting to move away from materiality, in itself, toward sociomateriality is to develop a nuanced language that does not betray the relational orientation. We found it quite difficult to keep the material in the storyline without falling from one side to another – either leaving the material realm unexamined, or emphasising the agency of the material to the detriment of understanding the entangled practice'*

According to Mutch (2013), although these discrepancies may be considered the result of a lack of appropriate language to express complex relationships, two other considerations emerge from a more detailed analysis of the work; a lack of specificity about the material world and a neglect of broader social structures.

In order to highlight the above concerns, Mutch (2013, p.31) considers the ethnographic study undertaken by Nyberg (2009, p.1193) in his discussion on call centre work as highlighted below:

> *'during the performance of a customer service call, the computer system, the keyboard, the screen, the telephone and the Customer Service Operator (CSO) all became one figure in relation to the customer. No boundaries were experienced between actors. The orientation was towards the engagement in practice, rather than the parts performing it'.*

Mutch (2013, p.31) argues that from this perspective Nyberg (2009) is almost totally 'dependent upon his informants for his view of the material factors that come into play', and that 'our knowledge of the sociomaterial understanding is limited to their understanding'. Hence Nyberg (2009) is considered to discuss the different forms of agency to 'the system' and to discuss it in ‘anthropomorphic terms’. Although such descriptions are deemed to be interesting and important they are considered ‘far from an adequate account of the sociomaterial entanglement’ (Mutch, 2013, p.31).

Although Nyberg (2009) is dealing with distinct material components, researchers such as Orlikowski and Scott, (2012) and Introna and Hayes (2011, p.114) face another problem in specifying the key material component within their studies. In these examples the material focus of the research ‘TripAdvisor’ (Orlikowski and Scott, 2012) and a ‘plagiarism detection system’ (Introna and Hayes, 2011, p.114) are both considered proprietary software and hence commercially sensitive. Although Mutch (2013) considers it unfair to criticise a lack of material specification in these instances, he does however highlight a lack of consideration for broader social structures. Although an appreciation of the materiality of ‘TripAdvisor’ is considered to change the role of ‘guest’ and ‘hotelier’, it does not do so in a ‘fashion that one might expect from a full blown sociomaterial perspective’ (Mutch, 2013, p.31). An under appreciation of the broader social structures ‘renders it difficult for analyses to take full account of factors such as power’ (Mutch, 2013, p. 32).

Leonardi (2012) takes this argument one stage further suggesting that although there is much to be gained from adopting an agential realist perspective, this presents empirical problems because ‘actors in the world do not perceive the material and the social as interpenetrated entities’ (Leonardi, 2013, p.66). Leonardi (2013, p.66) highlights that ‘actors of the world’, or ‘normal human beings’ (Sutton, 2010) could easily point to a hammer as being ‘material’ but would likely have a hard time ‘fathoming that a hammer was in any way social’. This is considered to have an empirical implication, if as a researcher you ‘strive to take the point-of-view of the actors they observe’ (Leonardi, 2013, p.66).

3.8.3 Absence of a theory of temporality

Thirdly Mutch (2013) argues that an approach to sociomateriality, based on ‘agential realism’ in practice ignores time. With regard to the concept of sociomateriality Mutch (2013, p.32) states the following:

> *‘Social life here is reduced to the practice reflected on by particular informants and contingently observed by an external party. That such approaches can yield rich material is not in question, but social structures are not necessarily transparent to participants. The approach above ignores the role of time in producing particular constellations of position practice that emerge from the activity of persons, but are not reducible to that activity. Most crucially, the conditions in which such practice occurs were not produced by those now here present’*

Leonardi (2013, p.67) concurs with the above concern and argues that both ‘organisations and people’s practices exist in time’ and without a consideration of time, no analyst could explain why practices arise, endure or change. This factor is deemed to be a significant concern for researchers wishing to integrate to other organisational theories such as evolutionary theory (Kenney, 2012; Attolini and Michor, 2009) or neo institutional theory (DiMaggio and Powell, 1983; Meyer and Rowan, 1977). Within the context of this research, the absence of a theory of temporality makes it difficult to identify factors affecting the homogeneity of working practice across the two sites. Within this context DiMaggio and Powell (1983, p.147) identify three processes by which organisational isomorphism occurs. ‘Coercive isomorphism’ occurs from both ‘formal and informal pressures exerted on organisations by other organisations, upon which they are dependent, and by cultural expectations in the society within which organisations function’ (DiMaggio and Powell, 1983, p.150). Within the context of this research coercive isomorphism can be seen by the influence of the UK government on pathology services. The second route is that of 'mimic processes' that occur as a result of organisational uncertainty, i.e. when 'organisational technologies are poorly understood, when goals are ambiguous or when the environment creates symbolic uncertainty' (DiMaggio and Powell, 1983, p.150). The third source of organisational uncertainty is that of 'normative pressures' which stem predominantly from 'professionalisation' or the drive for the legitimation of 'professional autonomy' (DiMaggio and Powell, 1983, p.152).

3.8.4 Sociomaterial relationships are considered to be mutually constitutive

In addition to the three concerns highlighted above, Leonardi (2013) identifies a fourth problem with the agential realist view of sociomateriality in that it treats all relationships as 'mutually constitutive or co-dependent' (Leonardi, 2013, p.66). This concern would appear to go to the heart of the agential realist view of sociomateriality and has been explored in detail by Faulkner and Runde (2012).

Drawing primarily from three references, Orlikowski (2007; 2010) and Orlikowski and Scott (2008b), Faulkner and Runde (2012, p.52) consider three key interdependent themes as highlighted below:

- **Relationality** – Entities whether human of technological, are in some ways constituted by the relationships they stand to each other.
- **Interpenetration** – The human and the technological are fused or interpenetrated
- **Agential cuts** – The lines between things ("agential cuts") are drawn and enacted by 'agencies' of observation and are 'performed' rather than being intrinsic properties of those things

The first concern relates to the notion that ‘people and things only exist in relation to each other’ (Orlikowski and Scott, 2008b, p.455). While acknowledging that that the social world is highly relational problems arise if we adopt the position that every relation is constitutive. Constitutive relations or ‘internal relations’ (Faulkner and Runde, 2012, p.53) are considered to be ones in which the individual elements within the relationship contribute to making the whole. According to Faulkner and Runde (2012, p.53) restricted to binary relationships there exists a relationship between any pair of relata X and Y if:

X would not be what it is for the existence of Y, or
Y would not be what it is for the existence of X, or
X would not be what it is for the existence of Y and Y would not be what it is but for the existence of X.

However not all relations are internal, some relationships can be considered ‘external in the sense that although the two are related, they do not need each other (or one does not need the other) for either to exist’ (Faulkner and Runde, 2012, p.54).

In order to highlight this form of external relationship Faulkner and Runde (2012, p.54) utilise the postman and dog metaphor as highlighted below:

> *‘While postmen and dogs often have an intimate and typically fraught relationship, it is probably not the case that this relationship is constitutive of either postmen or dogs. That is to say, at least as we see it, having interacted with a dog is not a necessary condition for someone to be a postman, just as having interacted with a postman is not a necessary condition for a four-legged creature that barks to be a dog. And if so, then all relations between postmen and dogs are external rather than internal relations. The same goes for the relations between many other things’*

According to Leonardi (2012, p.67) 'the problem with treating all relationships as mutually constitutive is that analysis overlooks how and why phenomena get put into relationships with each other, and consequently, how their relationship might change phenomena other than then themselves'.

Robey, Raymond and Anderson (2012, p.218) also support preserving the distinction between the material and the social contexts of use. Although this is not considered to imply that technology determines social consequences it does imply a 'functional relationship' between them.

The second of the three themes relates to the notion that the social and the material are in some way 'constitutively entangled' (Orlikowski, 2007, p.1437) or 'interpenetrated' (Orlikowski and Scott, 2008b, pp.455-456). According to Faulkner and Runde (2012. p.56) the notion of 'interpenetration' 'entanglement' and 'intra-action' developed from Barad's (2003) philosophy goes well beyond the concept of internal relations.

While it is appreciated that the concept of 'interpenetration' may be intended metaphorically along the lines of Haraway's (1991) 'cyborg manifesto', Faulkner and Runde (2012) reject the concept on operational and empirical grounds. Although there are limited cases where the interpenetration metaphor would be applicable, such as 'artificial hearts and hips, bullets and so on', it is more difficult to envisage a world in which 'machine operators meld physically with the machines they operate or computer programmers with the computer programmes they write' (Faulkner and Runde, 2012, p.57).

The third concern identified by Faulkner and Runde (2012) builds on the first two themes and has a significant consequence for anyone wishing to undertake empirical research. According to Faulkner and Runde (2012, p.58):

> *'if the contents of the world are not separated by intrinsic boundaries as Orlikowski and Scott (2008b) would have it, on what basis do we distinguish between things, be this in our capacity as researchers or simply as people going about our everyday affairs?'*

According to Barad (2003) the boundaries are formed by specific 'material discursive practices' or 'agential cuts'. Faulkner and Runde (2012, p.59) concur with Orlikowski, Scott and Barad in so much as the drawing of boundaries (making agential cuts) is 'intimately connected with creating categories of things'. However they raise concerns as to whether a concept, developed at the subatomic level, can be adopted within the social realm. Can social scientists or ordinary individuals make 'agential cuts' and if so do they make them during the course of their normal business? In essence are people 'constantly creating their worlds as they are negotiating them' or do they proceed on the basis of agential cuts made by 'prior generations' (Faulkner and Runde, 2012, p.59).

In answer to these questions Faulkner and Runde (2012, p.59) acknowledge the general concept that it is 'materially and discursively situated humans who draw boundaries between things such as language and technology'. They also accept that these boundaries can be fluid in that items of technology can move between boundaries. However it is acknowledged that most boundaries and categories are relatively stable. Once an object has been generally accepted to fall into a category, it is argued that whether or not something falls into one category or another depends 'not on observers with but the way the world is'. Thus once we have agreed a category for example that a bicycle is a twowheeled vehicle with handle bars and a saddle then the whether or not the object in front of us is a 'bicycle' and not a 'porcupine' is not something that depends on us as observers, but on 'the extent to which it has the features just listed' (Faulkner and Runde, 2012, p.60).

3.9 Sociomateriality from a critical realist perspective

To address these concerns Mutch (2013) suggests that critical realism (Volkoff, Strong and Elmes, 2007; Strong and Volkoff, 2010) and in particular the 'morphogenetic approach' of Margaret Archer (1995) offers an alternative to agential realism as a theoretical foundation for research into sociomateriality.

Denzin and Lincoln (2005, p.13) consider critical realism to be part of the antipositivist movement, most closely associated with the works of Roy Bhaskar (1995). The use of the term critical in this context refers to a 'transcendental realism that rejects methodological individualism and universal claims about truth'. A critical realist approach accepts the positivist epistemology that there is a 'world of events that is out there waiting to be discovered' (Denzin and Lincoln, 2005, p.13), however they accept that knowledge about this world is socially constructed. It is argued that in rejecting a 'correspondence theory of truth', 'reality is arranged in levels and that scientific work must go beyond statements of regularity to analysis of mechanisms, processes and structures, that account for the patterns that are observed' (Denzin and Lincoln, 2005, p.13).

According to Archer (1995, p.165) society is not a mechanism with 'pre-set preferred states'; it is not a language with an ordered syntax, nor is it comparable to a cybernetic system capable of carrying out goal directed, feedback regulated, error correction'.

Society is considered to be an open system, because it is 'peopled', and being 'peopled' can always be reshaped through human innovativeness. Archer (1995) uses the term 'morphogenesis' to illustrate this social shaping as illustrated below:

> *'Hence the use of the term morphogenesis to describe the process of social structuring; 'morpho' indicating shape and 'genesis' signalling that the shaping is the product of social relations. Thus morphogenesis refers to those processes, which change a system's given form, state, or structure. Conversely, morphogenesis refers to those processes in complex system-environmental exchange, which tends to preserve or maintain a system's given form, organisation or state' (Archer, 1995, p.166).*

Within the morphogenetic approach human and social elements of everyday life are considered to be ontologically distinct but none the less intricately interlinked, as they temporarily emerge from different strata as highlighted below:

> *'the emergentist substitutes analytical dualism. Because the social world is made up, 'inter alia', of structures and of agents and because these belong to different strata, there is no question of reducing one to the other or of eliding the two and there is every reason for exploring the interplay between them world' (Archer, 1995, p.62).*

> *'the central argument is that structure and agency can only be linked by examining the interplay between them over time, and that without the proper incorporation of time the problem of structure and agency can never be fully resolved' (Archer, 1995, p.65)*

Cruickshank (2012, p.73) argues that these ontological assumptions consider the world to be a 'stratified open system', in which 'unobservable causal laws interact in contingent ways to produce change at the level of observable events'. Reality is held to be a 'stratified' property, which cannot always be reduced to the level of physics. Disciplines such as chemistry and biology are thus seen to 'emerge' from the level of physics but which are irreducible to the level of physics. In this context water is an emergent property of hydrogen and oxygen but is irreducible down to these components and has its own properties. A critical realist stance research will not be taken to yield certainty in knowledge and theories are still ‘fallible interpretations that are open to criticism and revision or replacement in the future’ (Cruickshank, 2102, p.73).

The adoption of a critical realist perspective allows researchers to specify the nature of material properties whilst at the same time encompassing an appreciation of differing ‘levels and features’ (Mutch, 2013, p.37). In doing so this approach allows us to be ‘specific about the materiality we are engaging with and to enable our approach to cover the full range of instantiations’ (Mutch, 2013, p.37).

3.9.1 Implications for sociomateriality of adopting a critical realist approach

A summary of the concerns raised by adopting an agential realist perspective and the associated potential solutions of adopting a critical realist approach are summarised in Table 8 below:

Table 8. Problems for sociomateriality arising from agential realism (Leonardi, 2013, p.66)

Problems arising from the adoption of "agential realism"	Reasons why problem exists	Solutions to problems from the adoption of critical realism	Reasons why problems are avoided with "critical realism"
Lack of explanatory power (of empirical phenomena)	Conflation of realms of action and structure precludes examination of "becoming" and shifts the focus to what is which leads to descriptive studies	Treating materiality as existing in the realm of structure and social action in the realm of action	Use of an analytical dualism between structure and action.
Inability to perform empirical studies that actually demonstrate "sociomateriality"	Empirical operationalization forces scholars to define, at least implicitly what is "material" in the context they are studying.	Shifts locus of explanation from what things are to why they appear to be as they are	Ontological separation of "social" from "material".
Overlooks how practices are sustained and changed	Absence of a theory of temporality due to conflation of social and material	Specifies mechanisms that link social and material over time	Includes a specific theory of temporality
Treats all relations as mutually constitutive or co-dependent	Reliance on a thesis of "interpenetration" and a conceptualisation of the social and the material as internal relations	Examines how "social" and the "material" become constitutively entangled to produce the "sociomaterial"	Employs a theory of morphogenesis to argue that materiality as a structural property, pre-exists action-peoples use of technology

In conclusion Leonardi (2013, p.73) states the following:

> *'a theoretical foundation of agential realism is in no way a wrong or bad turn, or in any way worse than a foundation on critical realism. They are simply different and one may be better suited for particular contextual circumstances. By making comparisons of this kind and exploring their value for understanding technology and organising, scholars who examine the most practical of all phenomena may be able to find a path out the interesting, important and dense philosophical forest into the open fields of practical utility'*

Scott and Orlikowski (2013) also respond to the criticisms raised by Mutch (2013). Rather than considering the concept of agential realism as a ‘wrong turn’, ontological presumptions surrounding non-separability, are considered to be a strength rather than a weakness.

Scott and Orlikowski (2013, p.78) argue that Mutch (2013) focuses a large part of his discussion of what they term first generation papers, which draw on the work of Barad (2003). This ‘critique by proxy’ is considered to be problematic and cannot be considered ‘credible evidence against the original work’. A central theme of the argument developed by Mutch (2013) revolves around the inability of the relational ontology developed by Barad (2003) to adequately deal with ideas that are central to critical realism i.e. those of emergence and stratification. Scott and Orlikowski (2013, p.79) argue that this is unsurprising as highlighted below:

> ‘Berating agential realism for supplying “a shaky foundation” to social science (Mutch, 2013, p. 35) is simply misplaced. Suggesting as much is akin to censuring critical realism for offering a shaky foundation to geological analyses.

Although the sociomaterial approach is considered a ‘wrong turn’ by Mutch (2013), Scott and Orlikowski (2013, p.79) argue that it is unclear why the critical realist approach should be considered the right turn. It is argued that a level of critique, which opts for ‘exclusionary declarations’, is unhelpful and at odds with what the work is trying to achieve.

In conclusion Scott and Orlikowski (2013, p.80) call for a settling of the differences as highlighted below:

> *'The challenge and opportunity is to turn unsettled and unsettling ideas into inspiration, and differences into analytical edge for deepening understanding so that we might understand the world anew. It flows from this that ruling out novel perspectives and stifling innovation is likely to undermine any field of study'.*

Scott and Orlikowski (2013, p.80) counter the criticism of Mutch (2013) by asking that 'scholars engaged in studies of information systems and organisations adopt 'whatever theory they find works best for the research they pursue' rather than ruling out novel perspectives.

3.10 Development of research framework and questions

According to Styhre (2011, p.386) sociomaterial practices are still relatively crude in terms of being based on the two "grand" concepts of "the social" and "the material". These two concepts are described as 'black boxes' (Styhre, 2011, p.386) that need more detailed analysis. Although considered useful when 'sketching broader theoretical frameworks' the concept remains 'too general' and 'too imprecise' to be of any significant help in actual empirical studies (Styhre, 2011, p.386).

A potential route to investigate these two 'grand concepts' is provided by Leonardi and Barley (2008) in their reconceptualisation of the sociomaterial debate, which provides the theoretical framework for this research.

According to (Leonardi and Barley, 2008, p.164)

> *'to integrate materiality with a more voluntaristic stance requires that researchers attend directly to the specific ways in which the features of particular artefacts' become entangled in the social practices of peoples work. In addition to paying attention to studying the social dynamics such as perception and interpretation this means paying attention to studying what a technology lets users do, what it does not let them do and the workarounds that they develop to address the latter'.*

3.10.1 Determinism v Voluntarism & Idealism v Materialism

According to Leonardi and Barley (2008, p.160) 'although theorists may argue that social and material factors are equally important most papers on the creation, perpetuation or change of technologies and organisations, eventually favour one or the other'. The authors go on to state that the main reason for this is the tendency is to 'confuse two important but separate philosophical distinctions, the difference between determinism and voluntarism on the one hand and materialism and idealism on the other' (Leonardi and Barley, 2008, p.160).

Within this context determinism holds that our actions are caused by external forces including technology and culture, which exist 'independently of and typically prior to the behaviour of interest' (Barley, 1998, p.249). Alternatively a voluntaristic approach proposes that individuals have 'free will' (Leonardi and Barley, 2008, p.160) and can thus shape their own destiny.

Barley (1998, p.249) goes on to state that 'the second dilemma, materialism v idealism concerns types of causes rather than the nature of causality itself'. Materialists hold that human action stems from 'physical contexts and causes such as geography, biology, climate and technology'. Conversely idealists argue that 'ideas, norms, values, ideologies and beliefs are what drive human action' (Barley, 1998, p.249).

According to Barley (1998, p.250), researchers frequently assume that determinists also advocate materialism, exemplified by the works of Karl Marx's writings, associated with 'historical materialism'. Alternatively this approach has been countered in the literature by the social constructionist's idealist/voluntaristic approach, which argues that workers' social practices, beliefs and cultures significantly influence how technologies shape an organisation (Pinch and Bijker, 1984; Barley, 1986; Orlikowski, 1992). Neither perspective however 'exhausts the universe of viable visions of technology and organising' (Leonardi and Barley, 2008, p.160).

Braverman (1974), for example, is considered to have taken a deterministic/idealistic stance when he argued that 'technological de-skilling was the inevitable outcome of a dominant managerial ideology, that stressed the separation of conception from execution' (Leonardi and Barley, 2008, p.161). The emphasis here is that technology itself does not de-skill workers and that in this example it was the ideas, norms and values of managers that created the changes.

Finally Barley (1998) goes on to state that it is also possible to be a materialist and a voluntarist as illustrated by the human factor and ergonomic literature (Cacciabue and Vella, 2010; Beuscart-Zephir, Aarts and Elkin, 2010; Duffy, 2011; Bernonville et al. 2010). This perspective argues that technology directly shapes human behaviour. However 'because technology is designed by humans and because these designs can be altered, humans can both intend and change the social effects of a technology by redesigning it, or failing that refusing to use it' (Leonardi and Barley, 2008, p.161)

In order to investigate the sociomaterial impact within an organisational environment Leonardi and Barley (2008, p.161) identify four challenges for theory building, which need to be addressed as follows:

- To recognise that it is possible to talk about a technology's materiality without also being a determinist.
- To broaden the range of technologies that contemporary researchers normally choose to study.
- To stimulate researchers to study the relationship between developments in use in order to understand how the practices of designers affect users and vice versa.

According to Leonardi and Barley (2008, p.161) addressing the issues highlighted above will enable scholars to build a better theory about the role of materiality in the process of organising.

3.10.2 Bridging activities of development and use

According to Leonardi and Barley (2008, p.166), with a few notable exceptions (Orlikowski, 1996; Thomas, 1994; Leonardi, 2007) research into the effects of technology on organisations and users has traditionally focused on what happens before or after technology is introduced into a work setting.

Thomas (1994, p.4) argues that traditional research, which predominantly focuses on either the design or implementation phase of technology, is essentially flawed because both perspectives 'fail to capture the dynamic and interactive nature of the relationship between the technical and social systems of an organisation'.

The reasoning behind this division of labour is cited as 'ensuring research programmes can be accomplished in an acceptable timeframe' (Leonardi and Barley, 2008, p.166). Separating the design phase from use however is considered to have placed 'serious limitations on our collective ability to unravel the relationship between agency, the material and the social' (Leonardi and Barley, 2008, p.166). In particular, the development of a technology does not necessarily cease after users encounter it. Not only is user feedback to manufacturers critical to future developments, but also importantly users may themselves modify technology. Technologies are already social products when they arrive on the scene, but we treat the technology when it arrives as a 'black box' because we don't know about its prior social history (Leonardi and Barley, 2008, p.166).

Researchers wishing to study the co-evolution of the material and the social however, face a number of challenges. Leonardi and Barley (2008, p.167) state that 'we would expect it to be easier to study technologies that are both developed and used within the same organisation'. Conversely technologies, whose design and manufacture are remote from the user such as 'mass marketed word processing programs', will naturally pose more of a problem (Leonardi and Barley, 2008, p.167). In the middle of these two extremes are modifiable off-the shelf technologies such as enterprise resource systems and it is argued within this research automated pathology platforms. Typically the core elements of these technologies are already pre-programmed, but 'in-house' modifications are possible. In these cases 'feedback between use and re-design should occur relatively quickly and be relatively easy to trace' (Leonardi and Barley, 2008, p.167). Finally Leonardi and Barley (2008, p.167) state that 'when developers and users of such technologies are located in different organisations, researchers may even be able to track how changes in one organisation affect changes in another' (Leonardi and Barley, 2008, p.167)

Thomas (1994, p.4) offers another possibility as to why traditional research has neglected the process of change, in that it cannot be represented as an easily quantifiable variable such as structural outcomes, which can be enumerated and compared. Activities associated with the configuration and actual use of technology are pushed into the background in order to obtain a cross sectional 'snap-shop of the outcomes of change' (Thomas, 1994, p.4). Thus 'proxy measures are substituted for direct investigation', for example 'Research and development expenditure as a fraction of gross revenue serves as an indicator of ability to change, number of days lost to work stoppages substitutes for worker resistance to change' (Thomas, 1994, p.11).

The process of technological change is however considered by Thomas (1994, p.4) to occur within a social and historical context 'embedded interests and ideologies about what problems can or should be solved by technology'.

Traditional research is then bounded on one side by a decision to introduce technology and on the other by the incorporation of technology into routine operation; as a result the process is equated to 'implementation'. A failure to bridge the gap between design and use therefore represents a failure to gain a complete picture of the relationship between an organisation's technical and social systems. Traditional research is based on a hierarchy of attention, which focuses in order of importance on spectacular successes, followed by spectacular failures (Thomas, 1994, p.12). Least likely to be studied are the 'alternatives considered but not selected', followed by the change options 'disqualified from serious consideration because they violate existing assumptions about the "proper" way to structure work' (Thomas, 1994, p.12). Thomas (1994, p.12) argues that consideration of 'unorthodox propositions' are likely to provide 'critical insight as to how and why a technology comes to be recognised as a candidate for adoption'. In order to gain a full appreciation of the impact of technology on organisations it is therefore important to include analysis of the full range of activities associated with the introduction of a new technology, including the 'identification' and 'selection' process, as well as the 'implementation' phase (Thomas, 1994, p.13). For the purposes of consistency and comparison Thomas (1994, p.32) define 'three "moments" in the change process' as follows:

- Choosing between technologies, that is the activities involved in selecting among alternative approaches to a given task. For example, this moment would include choices between a manual and an automated production process
- Choosing within the technology, that is, the activities involved in selecting among alternative approaches within a given technology. For example, this moment would include choices about the degree of automation to be employed in a production process.
- Implementing the chosen technology, that is, the activities involved in selecting among alternative approaches to operating the chosen technology. For example this moment would include choices the manner in which skills and operational control will be distributed.

3.10.3 Secondary research questions

According to Leonardi and Barley (2008, p.167) studying on-going cycles of design, use and modification, provides a strong strategy for untangling the relationship between agency, the material and the social because it can treat both the social and the material as emerging, evolving and entwined. From this perspective the question is not whether technologies change through use, but rather, what processes lead to change and what determines the pace of change (Leonardi and Barley, 2008, p.167).

In order to untangle the relationship between the social and the material this research will then focus of the design, use and modification of LSPA technology within two UK NHS pathology laboratories. In order to bridge the gap between the design and use of LSPA four secondary research questions have been identified and are highlighted below:

- **Do the developers of LSPA purposefully intend their technologies to shape the work practices of users or the structure of organisations?**
- **If so how do designers of LSPA technology embody their intentions in designs?**
- **Do such designs intentions subsequently have their effect in practice?**
- **If so why, if not why not?**

3.11 Summary

In conclusion this chapter has challenged the traditional technical versus social debate, prevalent in social science studies of technology, by proposing the adoption of a relational 'sociomaterial' (Mol, 2002; Suchman, 2007) perspective. The literature review however has revealed that the concept of sociomateriality is a heterogeneous framework, based on multiple ontological perspectives some of which are not mutually exclusive. The 'agential realist' (Barad, 2003) perspective considers the relationship between the material and the social to be inextricably linked, 'there is 'no social that is not material and no material that is not social' (Orlikowski, 2007, p.1437). Other researchers (Mol, 2002: Pickering, 1995; Leonardi, 2011) have challenged this perspective and whilst considering the material and social to be interlinked, maintain the ontological divide between the two. More recently in the literature it has been suggested that the concept of sociomateriality would benefit from refreshing existing social theories (Robey, Raymond and Anderson, 2012). In order to explore alternative options the concept of sociomateriality has been reviewed from a critical realist perspective. Critical realism as conceptualised in the 'morphogenetic' approach of Archer (1995) would appear to offer significant theoretical advantages over 'agential realism' (Barad, 2003) with regard to temporality and considerations broader social structures such as power (Mutch, 2013). From a practical perspective the concept of sociomateriality has also been criticised as being 'too general and imprecise' to be of any help in empirical studies.

Leonardi and Barley (2008) offer a potential solution to untangle the relationship between the social and the material by investigating the design, use and subsequent modification of technology in practice.

Initially this research will investigate the design intentions of suppliers of LSPA technology with regard to changing the organisational structures and working patterns of user organisations. The focus of this research will then shift to the selection process and subsequent implementation and use of LSPA within two NHS Pathology laboratories. This practice-based research will then utilise the sociomaterial concept of affordances and constraints utilised by Pickering (1995) and Leonardi (2011) to explore the impact of LSPA on both a micro and macro scale. It is envisaged that this sociomaterial investigation will provide a unique opportunity to investigate the influence of technology on organisations and enable us to gain a novel understanding of the 'reality' of Pathology itself.

Chapter 4 Methodology

4.0 Introduction

The previous Chapter 3 of the literature review concluded with a requirement to understand the development of pathology services and the introduction of technology within this environment from a sociomaterial perspective. According to Leonardi and Barley (2008, p.164) in addition to ‘paying attention to studying the social dynamics such as perception and interpretation, sociomateriality is best unpicked by also paying attention to studying ‘what a technology lets users do, what it does not let them do and the workarounds that they develop to address the latter’.

Accordingly the focus of this research will be an investigation into the development of pathology laboratory services following the introduction of LSPA within two NHS Laboratories. This work will then focus not only on the social dynamics and perceptions of LSPA designers and pathology management but on the performed realities within the laboratory, including a review of the affordances, constraints and workarounds developed as a result of this technological change.

It is acknowledged during the course of this research that the empirical and theoretical strands have evolved in parallel. In order to provide context for the reader an overview of the timelines from both perspectives has been provided at the beginning of the methodology and diagrammatically illustrated in figures 3 and 4. In addition, the timeline of theories and key concepts (figure 4) includes a selective number of pivotal references, identified in chronological order by the author during the course of this research and subsequently included in the review text (section 4.1)

Figure 3. Empirical timeline

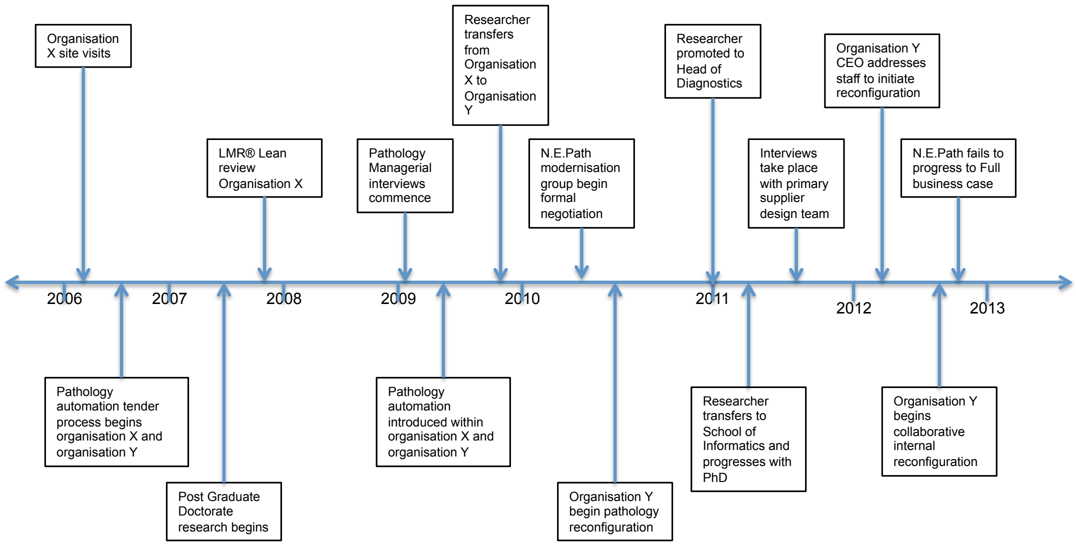
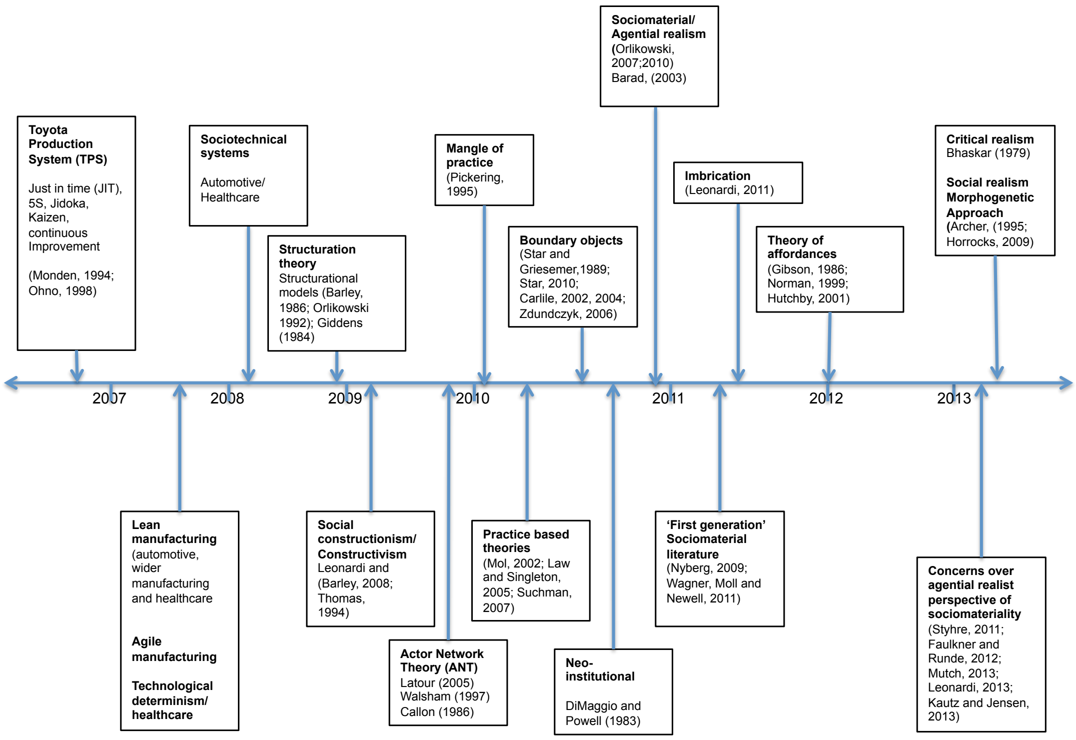


Figure 4. Timeline of theories and key concepts utilised during this research



4.1 Parallel development of evolving empirical study and theories utilised during this research

During 2006, Organisation X entered into formal discussions with the primary supplier of LSPA, to replace the majority of equipment within the departments of haematology and biochemistry. In my role as Haematology Service Manager, I was involved in the entire selection process, which included contributing to the production of the tender documentation and participation in site visits to other user organisations, both home and abroad.

During 2007 I was offered the opportunity to undertake a Post Graduate Doctorate in Biomedical Science, within the School of Applied Science at Northumbria University. Building on a programme of research undertaken previously as part of a Master of Business (MBA), my area of academic interest centred on the impact of technological change within a healthcare environment, from both a structural and cultural perspective.

During this early period and quite by coincidence, the CEO of Organisation X was approached by an external management consultancy, Lean Manufacturing and Resourcing (LMR®). Following discussion, the CEO issued a request for any interested party to come forward and work with this consultancy group in order to gain first-hand experience of the Toyota Production System (TPS). From both a professional and academic perspective I considered this to be a great opportunity. The output of this work included the application of lean production techniques within the central reception area of Organisation X. The impact of these changes would eventually be observed to create a sociomaterial ‘mangle of practice’ (Pickering, 1995) within that particular environment, following the introduction of LSPA (section 6.10).

This initial empirical work required a sound theoretical understanding of the basic principles of the TPS, including production techniques such as Just-in-time (JIT) and the concept of continuous improvement (Monden, 1994; Ohno, 1998). Following this initial review, my interest widened to include the influence of TPS within the wider automotive industry, non-automotive manufacturing and eventually healthcare, including pathology. As an adjunct to this work I also gained an understanding of 'agile' manufacturing techniques. Although not utilised during the course of this research, this learning did influence my professional practice and led to improved supply chain relationships with NHS Blood and Transplant, with regard to the supply of blood and blood products (Shaw and Grey, 2011).

This critical review of lean manufacturing techniques also highlighted some perceived deficiencies, particularly with regard to overcoming cultural barriers to change. The cultural difficulties of implementing wide-scale technological change, within an NHS pathology environment, had already been identified during the course of my MBA research (Wainwright and Shaw, 2007; 2008; 2013).

From an empirical perspective, however with the management consultants from LMR® made me question the necessity and perceived benefit of LSPA within Organisation X (section 6.7.1). This initial period of research appeared to fundamentally change my perception of the impact of technology on organisational design. Even though I had worked with pathology equipment for decades, this group helped me to appreciate the possibility of utilising pathology technology in a manner unexpected by the supplier. The operation of relatively fixed function technology i.e. technology not readily open to user modification, could still be approached with a degree of 'interpretive flexibility'

(Pinch and Bijker, 1984, p. 421) by humans. In essence, humans engaging with relatively fixed function technology, could selectively chose to utilise the features imbedded in the design of the technology, or not, as they saw fit. The work with LMR® allowed me for the first time to truly gain an appreciation of an artefacts ‘materiality’, the physical or digital materials that are considered important by users.

Further to the work undertaken within the laboratory, the opportunity to engage with users of the pathology service revealed the entire process from the taking of a blood sample, to the generation of a result, was highly complex. The pathology process was then conceptualised as an interdependent network of patients, clinical staff, porters, blood tubes barcodes and related interdependencies. From an empirical perspective it became apparent that in order to make improvements to either organisational routines or technology, it was vital to understand this complex sociomaterial network as a whole, rather than focus on either the material or social elements in isolation.

Following this initial empirical work, I then began a retrospective theoretical investigation into the impact of technology from both an objective and subjective perspective. Whereas technological determinism looked to make law like claims about how technology would or should influence formal organisational structures, the sociotechnical theorists argued that technology could bring about varying and unexpected changes to organisational form. Within this context structuration theory (Giddens, 1984; Barley, 1986) and the subsequent structurational models of technology (Orlikowski, 1992) were particularly influential.

Despite my empirical and theoretical concerns, both Organisation X and (unbeknownst to me at the time Organisation Y) completed the selection process during late 2006. In 2007 both organisations began installing LSPA technology, provided by the same primary supplier identified during the course of this research.

In order to investigate the goals and perceptions of other pathology managers, undertaking, or considering undertaking, similar initiatives within the North East of England I began a series of semi-structured interviews in 2009 the results of which can be seen in (section 6.1).

Following the installation of LSPA technology within Organisation X, changes to organisational structures and routines, were observed to create a sociomaterial 'mangle of practice' (Pickering, 1995) within the central reception area. These changes resulted in periods of over and under production within this area (section 6.10). The identification of the sociomaterial affordances and constraints of LSPA would later play a pivotal role in the development of the theoretical model developed during the course of this research.

From a theoretical perspective, I was highly influenced during this period by the work of Leonardi and Barley (2008). This group highlighted that is was possible to appreciate artefacts materiality without resorting to determinism, by paying attention to the particular ways a material artefact becomes entangled in the social practices of peoples work. A review of the literature revealed that in practice, the timelines for such investigations were usually short. As a result previous studies had focused predominately on the effects of technology before or after introduction into an organisational setting (Leonardi and Barley, 2008; Thomas, 1994). A failure to bridge the gap between design and use of technology therefore represented a gap in the literature, which this research aimed to exploit.

The concept of social and material elements of organisational life being considered ‘entangled’ (Orlikowski, 2007, p. 1437) rather than distinct entities led the author to investigate the impact of ANT on organisational development. The results of this research are evident throughout this work and are embodied within the sociomaterial model developed later in this thesis (section 8.1).

From a theoretical perspective my research into ANT also led to me to review other practice based frameworks, which considered the entanglement of both human and material agency. In particular, working in the field of science and technology studies the development of the ‘mangle of practice’ (Pickering 1995) was influential. From a philosophical perspective, considering sociomaterial interactions as being enacted ‘in-practice’ had the effect of blurring my initial conceptualisation of what it actually meant to be social or material. Rather than understanding material objects as being the central focus of human perception, objects manipulated ‘in-practice’ (Suchman, 2007; Introna, 2009) were considered to create ‘multiple realities’ (Mol, 2002; Law and Singleton, 2005).

At this point in time I was also made aware of the body of literature surrounding the concept of boundary objects (Star and Griesemer, 1989; Star, 2010; Carlile, 2002, 2004; Zdunczyk, 2006). A boundary object as defined by Star and Griesemer (1989, p.410) was initially conceived as ‘living in multiple worlds and having different identities in each’. The effects of boundary objects were then perceived to facilitate consensus between disparate social groups. The effect of boundary objects influencing common working practices appeared to be particularly relevant to a research design, which crossed multiple organisational boundaries. This research was then consolidated by a review of neo institutional theory (DiMaggio and Powell, Meyer and Rowan, 1977), which suggested that other social factors such as external management consultants were also important in the development of similar working practices, across organisational boundaries.

In 2010 I left Organisation X and took up the position of Lead Biomedical Scientist in Haematology within Organisation Y. As a result of this transfer I was able to compare and contrast the impact of LSPA technology within two differing organisational settings.

Following my appointment Organisation Y appeared to be facing the same issues integrating LSPA technology into the laboratory as I had witnessed in Organisation X. In order to address these issues I as researcher/manager, in conjunction with primary supplier management consultants, introduced the same changes to organisational routines that had been undertaken in Organisation X (section 7.4). Perhaps unsurprisingly the ‘mangle of practice’ (Pickering, 2005) created within Organisation X following the introduction of LSPA, was recreated within Organisation Y (section 7.5). Following this initial period of work, the management consultants employed by the primary supplier of LSPA, suggested more significant structural changes, which were seen to significantly influence strategic direction (section 7.7).

During 2010 Organisation Y were also facing external pressure following the formation of North East Pathology Modernisation (N.E.Path), a UK government funded pathology modernisation network. This external network were considering the consolidation of pathology services within the North East of

England which would have seen Organisation Y becoming either a centralised 'hub' expanding the remit of services or a smaller 'spoke' site providing only emergency work. The influence of the modernisation agenda was therefore considered to stimulate a strategic review of services within Organisation Y based on internal reconfiguration.

In 2011, I was subsequently promoted to Head of Diagnostics within Organisation Y, managerially in charge of the departments of Pathology and Radiology. Following this transfer I initiated the collaborative internal reconfiguration of pathology while at the same time contributed to discussions on the regional reconfiguration of pathology services as part of the N.E. Path modernisation agenda.

From an academic perspective 2011 also heralded changes within my research programme. Following my mid-point progression structural changes within the University of Northumbria together with the loss of my then principle supervisor saw me transfer from the School of Life Sciences to what is now the Faculty of Engineering and Environment. This transfer brought about changes in the supervisory panel and the academic transfer from Post Graduate Doctorate to Doctor of Philosophy.

From an empirical perspective my investigations into practice based studies developed into an in-depth study of sociomateriality (Orlikowski, 2007; 2010) developed primarily from the 'agential realist' perspective of Barad (2003). Over the next year and a half this body of work expanded into what Scott and Orlikowski (2013, p.78) consider 'first generation papers' exploring the impact of sociomateriality on organisational design, for example (Nyberg, 2009; Wagner, Moll and Newell, 2011).

Other influential authors considered during this period included Leonardi (2011) and the development of the ‘imbrication’ metaphor. The concept of ‘imbrication’ (Leonardi, 2011) like the ‘mangle of practice’ (Pickering, 1995) developed five years earlier, was premised on an understanding of the theory of affordances (Gibson, 1986; Norman, 1999; Hutchby, 2001). A retrospective review of this literature was therefore required, before I could develop my own sociomaterial model, produced during the latter stages of this research.

In 2011, I began a series of semi-structured interviews with members of the LSPA design team the results of which can be seen in section 5.4.1. These interviews were undertaken as a means of bridging the gap between design and use, by gaining an understanding of the intentions of designers with regard to influencing user organisation structures and working practices.

During 2012 Organisation Y was deeply embroiled in the reconfiguration of services and as a result staff were approached by senior executives to consider the alternatives of internal rationalisation or regional reconfiguration highlighted above. This work stimulated a collaborative staff led review of services, the results of which ultimately suggested that internal reconfiguration within Organisation Y was preferential to external rationalisation within the N.E Path network. Later that year the N.E. Path modernisation network failed to gather the requisite amount of support and as a result failed to progress the case for regional rationalisation to full business case. With regard to this research this event was considered to be an excellent juncture with which to bring the empirical time line to an end.

It has been acknowledged during the course of this research that the concept of sociomateriality has begun to have a significant impact on the research community and as such is an area of rapid development. Following the completion of my empirical work during the early part of 2013, key areas of concern were identified in the literature, predominantly with regard to the 'agential realist' conceptualisation sociomateriality developed by Barad (2003). These concerns included the theoretical limitations of conceptualising the material and social as mutually constitutive, an inability to perform empirical studies, coupled to a lack of unique explanatory power and the absence of a theory of temporality (Styhre, 2011; Faulkner and Runde 2012; Mutch, 2013; Leonardi, 2013; Kautz and Jensen, 2013). As a consequence of these concerns the agential realist perspective was perceived as being limited by an under-appreciation of time and the influence of broader social structures such as power. In order to overcome these perceived deficiencies, a number of authors (Mutch, 2013; Leonardi, 2013) suggested that the 'critical realist' theory of Bhaskar (1979) could provide a suitable framework with which to progress our understanding of sociomateriality and overcome some of the limitations of agential realism.

In response to these developments, the author utilised the 'morphogenetic approach' developed by Margaret Archer (1995) building on the 'critical realist' framework of Roy Bhaskar (1989) to develop a theoretical model to explore the development of sociomaterial relationships over time. The morphogenetic approach however does not formally acknowledge the role of technology in the change process. In order to overcome this deficiency the resulting model utilises key tenets of ANT as a means to 'render technology visible' (Mutch, 2002, p.488). The development of this model and practical application within a healthcare environment can be seen in (section 8.1 and 8.2).

The timeline for this part-time research has by necessity spanned many years, which brings both significant affordances and constraints. Long-term ethnographic study is considered to provide both a richness of data and the ability to trace the historical developments within two differing organisations. On the down side the research period is protracted and as research/manager it becomes difficult to estimate how much time has been spent independently on each activity. A conservative time estimate for this research is then highlighted in Table 9 below:

Table 9. Summary of data collection

Task	Duration (hours)
Site visits to organisations already utilising LSPA technology	120
Lean management project with LMR® in Organisation X	112
10 semi structured interviews with Pathology managers contemplating or utilising LSPA technology	7.5
5 Semi structured interviews with Primary supplier management consultants	3.75
Transcription and template analysis	81
Participant observation of process following implementation of LSPA within Organisation X	182
Participant observation of process following of LSPA technology in use within Organisation Y	120
Focus group work within Organisation Y	30
Participation in regional N.E.Path network discussions	60
Total	716

The following section of this chapter details the development of the methodological framework used during the course of the research. Initially this review begins with a brief overview of the relational ontological stance, which is highlighted in more depth by necessity within Chapter 3 (Sociomateriality). Following this review the analytical framework of Crotty (1998) is used as the basis to elucidate the epistemological stance, theoretical perspective, methodology and methods employed during this research. It is acknowledged during the course of this work that undertaking research in an area of management responsibility is associated with a number of advantages and challenges. Where necessary a detailed description of the actual methodology employed has been incorporated to distinguish this application from the generic text based methodology.

Finally the chapter will concludes with a review of the ethical considerations, generated as a result of this work. Of particular relevance here is the role of the researcher as employee/manager/leader within the NHS organisations under investigation and the resultant ethical dilemmas generated as a result of that relationship.

4.2 Ontological perspective

According to Burrell and Morgan (1979, p.1) ontological assumptions 'concern the very nature of the phenomena under investigation. The basic philosophical question here concerns whether the 'reality' being investigated 'is external to the individual – imposing itself on individual consciousness from without or the product of individual consciousness' (Burrell and Morgan, 1979, p.1). Blaikie (2007, p.13) argues that the nature of social reality is frequently reduced to 'two opposed, mutually exclusive categories: idealist and realist'. From an idealist perspective 'the external world has no independent existence apart from our thoughts' (Blaikie, 2007, p.13). Alternatively a realist ontology assumes that 'social phenomena have an existence that is independent of the human observer' (Blaikie, 2007, p.13). As highlighted in Chapter 3 (Sociomateriality) these two ontological extremes have been challenged by a group of researchers (Pickering, 1995; Knorr Cetina, 1997; Suchman, 2007; Barad, 2003; Latour, 2005) who have been working with a 'relational ontology' that 'rejects the notion that the world is composed of individuals with separately attributable properties' (Orlikowski, 2010, p.134). According to Mol (2002, p. 6) 'ontology is not given in the order of things, but instead, ontologies are brought into being, sustained or allowed to wither away in common, day to day, sociomaterial practices'.

Ontology is therefore concerned with the 'what is' as opposed to the epistemological position of 'what it means to know' (Crotty, 1998, p.10). According to Crotty (1998) the two concepts are frequently confused in the literature and tend to 'emerge together' (Crotty, 1998, p.10). With this in mind Crotty (1998, p.11) excludes a specific review of ontological perspectives from his research framework and suggest that we reserve the term ontology 'for those occasions when we do need to talk about "being". Accordingly the development of the sociomaterial relational ontology is comprehensively discussed in Chapter 3 (Sociomateriality).

4.3 Research design

The following review of the theoretical and methodological stance employed during this research will then utilise the framework produced by Crotty (1998, p.2) as a 'scaffold' with which to develop the rationale behind this research. A diagrammatic representation of the framework used during the course of this research is highlighted in table 10 below:

Table 10. Research design summary adapted from Crotty (1998)

Research design	Explanation
Aim of the thesis	Develop a theoretical model to explore how sociomaterial networks involving large-scale automation, come into being, persist and change over time within a healthcare environment.
Philosophy	This thesis adopts a relational, performative ontology utilising social constructionism as the epistemological stance
Secondary research questions	• Do developers of LSPA purposefully intend their technologies to shape the work practices of users or the structure of organisations? • If so how do designers of LSPA technology embody their intentions in designs? • Do such design intentions subsequently have their effect in practice? • If so why, if not why not?
Theoretical perspective	Interpretivist, Symbolic Interactionist
Methodology	Multi-site ethnographic approach
Methods	Participant observation Unobtrusive data collection Semi structured and focus group interviews

4.4 Epistemology

According to Burrell and Morgan (1979, p.1) the epistemological debate is characterised by ‘assumptions about the grounds of knowledge or how one might begin to understand the world and communicate this knowledge to others’.

Crotty (1998, p.8) defines three primary epistemological stances namely ‘objectivism, subjectivism’ and ‘constructionism’. Whilst acknowledging that within this framework a number of authors have identified many subdivisions with regard to epistemological stance, this section will begin with an overview of the objective/subjective debate in order to provide context for the constructionist approach utilised during this work.

4.4.1 Objectivism

From an objectivist epistemology 'reality exists as such apart from the operation of any consciousness' (Crotty, 1998, p.8). The 'tree in the forest is a tree, regardless of whether anyone is aware of its existence or not' (Crotty, 1998, p.8). Viewed from this objective perspective the tree carries the 'intrinsic meaning of tree-ness', when humans recognise a tree they are simply discovering 'a meaning that has been lying in wait for them all along' (Crotty, 1998, p.8). In other words there is objective reality 'out there' (Gray, 2009, p. 18) and research is therefore concerned with discovering this objective truth.

From a theoretical perspective the objective epistemology is most closely aligned to the positivist theoretical perspective. From a positivist viewpoint, the 'laws' of nature or society can only be 'scientifically established' and 'verified by experience through our senses' (Crotty, 1998, p.25). According to Crotty (1998) the positivist movement reached its zenith with the Vienna Circle of logical positivism during the early 1900's. This group considered that knowledge produced via the senses or through scientific apparatus is factual, empirically verifiable and hence not open to question. The results of positivist research will tend to be presented as objective scientific facts and established truths. This perspective has however received criticism in the literature. Popper (1959, p.33) for example suggests that 'positive decisions can only temporarily support a given theory' as one example of 'falsification' also 'falsifies the theory from which they were logically deduced'. In another example of a rejection of the positivist notion, Kuhn (1970) has studied the development of science from a historical and philosophical position. According to Gray (2010, p.19) the positivist paradigm consists of ‘extending the knowledge of the facts by extending the match between those facts and the paradigms predictions, by further articulation of the paradigm itself’. Kuhn (1970) however notes that the production of scientific knowledge is not necessarily generated in this fashion and that often the established paradigm will be challenged by scientific revolution, such as Neil Bohr’s atomic theory or Darwinian evolution which will lead to the ‘rejection of one time honoured theory in favour of another incompatible with it’ (Kuhn, 1970, p.17).

Since this time the post-positivist movement has developed into a less arrogant form of positivism, which talks of ‘probability rather that certainty’ and claims a ‘certain level of objectivity rather that absolute objectivity’ (Crotty, 1998, p.29).

4.4.2 Subjectivism

From a subjectivist perspective meaning does not emerge out of an ‘interplay between subject and object but is imposed on the object by the subject’ (Crotty, 1998, p.9). The subjective perspective is however tempered by Crotty (1998, p.9) who states that we humans are ‘not that creative’, even from a subjective stance we make ‘meaning out of something’. Hence humans do construct meaning but do so from within collective unconsciousness, from dreams, from religious beliefs etc.’ (Gray, 2009, p.18). That is to say ‘meaning comes from anything other than an interaction between the subject and the object to which it is ascribed’ (Crotty, 1998, p.9). Hence what ‘one observer calls a tree another might call a shelter’ (Blaikie, 2007, p.19). From a research perspective the proponents of the subjective viewpoint look for evidence of ‘unobservable reality’ either in the ‘consequences it has on people’s lives or in the thought processes and structures of the mind itself’ (Blaikie, 2007, p.20). Despite subjectivism being considered 'the most slippery of terms' (Crotty, 1998, p.183), postmodernism can be taken as an example of a theoretical perspective linked to subjectivism.

4.4.3 Constructionism

According to Crotty (1998, p.42) constructionism can be illustrated by the following:

> *'the view that all knowledge, and therefore all meaningful reality as such is contingent upon human practices, being constructed in and out of interaction with human beings and their world, and developed and transmitted within an essential social context'*

From a constructionist perspective, there is 'no objective truth waiting to be discovered' nor is 'reality imposed on the object by the subject' (Crotty, 1998, p.9). Within this context meaning is constructed not discovered, and as a result individuals may well construct and assign different meanings to the same object. This factor is exemplified as we 'move from one era to another or from one culture to another' (Crotty, 1998, p.9). The social constructionist view of the world is then developed as human beings interact and engage in interpretation' (O'Leary, 2010, p.6).

Although definitions of social constructionism may be varied, Burr (1995, p.3) defines four concepts 'you would absolutely have to believe in to be a social constructionist', and these are as follows:

- A critical stance towards taken for granted knowledge – challenge the view that conventional knowledge is based upon objective unbiased observation.
- Historical and cultural specificity – the ways in which we commonly understand the world, the categories and concepts we use, are historically and culturally specific.

- Knowledge is sustained by social process – knowledge of the world is brought about by interactions between people in the course of social life.
- Knowledge and social action go together

Using the tree analogy highlighted above Crotty (1998, p.43) makes the following comments that the 'common-sense view commends to us that the tree standing before us is a tree'. However we must remind ourselves that it is 'human beings who have constructed it as a tree, given it the name and attributed associations we make with trees'. Hence "tree" is likely to bear quite different connotations in a logging town, an artist's settlement and a treeless slum'.

Within the context of this research the concept of construction has strong associations with that of materiality. In order to construct meaning we have to have something to work with and what we have is 'the world and objects in the world' (Crotty, 1998, p.44). In other words to be a human being means 'being-in-the-world', 'subject and object, distinguishable as they are, always united' (Crotty, 1998, p.45). According to Crotty (1998, p.47) 'what constructionism drives home unambiguously is that there is no true or valid interpretation', only useful interpretations, which stand over against interpretations that appear to serve no useful purpose'.

Crotty (1998, p.48) argues that the bringing together of the subjective and objective stance is however 'hardly characteristic of qualitative research today'. He argues that instead a 'rampant subjectivism' abounds turning for example phenomenology, from a study of 'phenomena as the immediate objects of experience, into a study of experiencing individuals'. Crotty (1998, p.49) cites Denzin and Lincoln's (2005, p.2) treatment of the researcher as 'bricoleur' adapted from Lévi-Strauss's The Savage Mind (Levi-Strauss, 1968) as a point in case. According to Crotty (1998, p.49) the researcher as 'bricoleur' involves being a Jack (or Jill) of all trades. The analogy made by Denzin and Lincoln (2005, p.4) is that of a 'maker of quilts' piecing together individual elements from 'multiple and gendered images of the scientist, naturalist, field worker or social critic'. From this self-reflexive perspective, 'Can I do it?' becomes the burning question' Crotty (1998, p.49). Crotty (1998, p.50) however offers another explanation of Lévi-Strauss's original intention. In the Savage Mind (Levi-Strauss, 1968) the 'bricoleur' is not someone able to 'perform a whole range of specialised functions', but rather the notion of 'a person who makes something new out of a range of materials' (Crotty, 1998, p.50). This distinction is fundamental when considering the role of objects and their inherent materiality within the context of this research. The question becomes not 'Can I do it?' but rather what can be made from these items? What do they lend themselves to becoming?' Within this context the preoccupation with materiality exists because according to Crotty (1998, p.51) they are the limiting factor. The possibilities contained within an objects' materiality, remain limited by 'the particular history of each piece and by those features which are already determined by the use for which it was originally intended or the modifications it has undergone for other purposes' (Lévi-Strauss, 1968). Hence within this research an attempt will be made to bridge the gap between design and use. In doing so the advice of Crotty (1998, p.51) will be taken 'to pay sustained attention to the objects of research' and not be 'straightjacketed by conventional meaning'. Instead the invitation is to approach the object in a 'radical spirit of openness to its potential for new richer meaning' (Crotty, 1998, p.51)

4.4.4 Social Constructionism

According to Crotty (1998, p.52) ‘if seeing interpretation as a making of meaning does not condemn us to subjectivism, it does not condemn us to individualism either’. The concept of constructionism, highlighted above, concludes that all objects are ‘made and not found’ by ‘interpretive motions’, which are both social and conventional’ (Fish, 1980, p.331). Fish (1980, p.331) concludes that the ‘mental operations that we can perform are limited by the institutions in which they are already embedded’. These ‘institutions precede us, and it is only by inhabiting them, or by being inhabited by them that we have access to the public and conventional sense they make’ (Fish, 1980, p.332). These interpretive strategies have as their source a ‘publically available system of intelligibility’ (Fish, 1980, p.332) or ‘cultural significance’ (Crotty, 1998, p.53).

The term social construction is however difficult to define and is often confused with constructivism. According to Young and Collins (2004, p.375) ‘constructivism’, ‘constructionism’, and ‘constructive’ are employed so idiosyncratically and inconsistently that at times they seem to defy definition’. According to Crotty (1998, p.58), ‘it would appear useful to reserve the term constructivism for the epistemological considerations that focus exclusively on the meaning-making activity of the individual mind and to use constructionism to define the collective generation [and transmission] of meaning’. In other words ‘constructivism proposes that each individual mentally constructs the world experience through cognitive process’ (Young and Collins, 2004, p.375). Social constructionism on the other hand focuses on the social rather than the individual. Social constructionism contends that ‘knowledge is sustained by social process and that knowledge and social action goes together. Social constructionism is then considered to be less interested, or not at all interested, in the cognitive processes that accompany knowledge' (Young and Collins, 2004, p.376). Thus 'constructivism points out the unique experience of each of us' whereas 'constructionism emphasises how cultures shapes the way in which we see things' (Patton, 2002, p.97).

Crotty (1998, p.58) however goes on to give some words of warning when taking a social constructionist approach. While constructivism tends to 'resist the critical spirit' in that each person's view of the world is equally as valid as the next, constructionism tends to foster it. Crotty (1998, p.59) argues that we tend to take 'the sense we make of things' to be 'the way things are', finding ourselves 'victims of the tyranny of the familiar'.

4.5 Theoretical Perspective

According to Crotty (1998, p.7), the theoretical perspective describes 'the philosophical stance that lies behind our chosen methodology'. The theoretical perspective is then regarded as an 'elaboration of the assumptions brought to the research task that are reflected in the methodology as we understand and employ it' (Crotty, 1998, p.7). According to Walsham (2006, p.320) interpretive methods of research start from the position that our knowledge of reality including the domain of human action is a social construction by human actors (Walsham, 2006, p. 320). A social constructionist approach will then by necessity require an Interpretivist theoretical perspective.

4.5.1 Interpretivism

According to Crotty (1998, p.67), the roots of Interpretivism can be traced back to the thoughts of Max Webber who suggested that in 'the human sciences we are concerned with *Verstehen* (understanding) as opposed to *Erklären* (explaining) found in the natural sciences. The Interpretivist approach is then conceptualised as a search for ‘culturally derived and historically situated interpretations of the social world’ (Crotty, 1998, p.67). Whilst the natural sciences look for ‘consistencies in data’ and ‘deduced laws (nomothetic)’, the social sciences often deal with the ‘actions of the individual (ideographic)’ (Gray, 2009, p.21). The aim of all interpretive research is then to understand how members of a social group, through their participation in social process, enact their particular realities and endow them with meaning, and to show how these meanings, beliefs and intentions of the members help to constitute their social action (Orlikowski and Baroudi, 1991, p.13). In doing so the interpretive researcher can never assume a ‘value neutral stance’, prior ‘assumptions, beliefs, values and interests always intervene to shape their investigations’ (Orlikowski and Baroudi, 1991, p.15).

Although Interpretivism is considered to come in many guises Crotty (1998, p. 71) identifies three historical streams have ‘borne it along’. In chronological order these are hermeneutics, phenomenology and symbolic interactionism. Although this work is considered to be within the realms of symbolic interactionism a brief overview of the other perspectives will be provided for context.

4.5.2 Hermeneutics

Derived originally from the interpretation of biblical texts modern day hermeneutics is an approach to the ‘analysis of texts that stresses how prior understandings and prejudices shape the interpretive process’ (Denzin and Lincoln, 2005, p.27). The aim of this technique is then to ‘gain an understanding of the text that is deeper or goes further than the authors own understanding’ (Crotty, 1998, p.91). Hermeneutic researchers, therefore, utilise qualitative methods to ‘establish context and meaning for what people do’

(Patton, 2002, p.115). As such the application of this technique is particularly relevant to 'reading theory and literary criticism' (Crotty, 1998, p.110).

4.5.3 Phenomenology

Phenomenology suggests that social reality has to be 'grounded in peoples experiences of that social reality' (Gray, 2009, p.22). Phenomenology therefore 'insists that we must lay our prevailing understanding of phenomena and revisit our immediate experience of them in order that new meanings may emerge' (Gray, 2009, p.22). Current understanding of phenomena must be 'bracketed' in order to let objects 'speak for themselves' (Gray, 2009, p.22). Phenomenology is then utilised to gain an individual subjective experience of a phenomena by attempting to 'put yourself in the place of the subject' (Gray, 2009, p.22).

Crotty (1998, p. 79) contrasts phenomenology with a constructivist approach, which is concerned with the individual engaging with objects in the world and trying to make sense of them. Constructionism according to Crotty (1998, p.79) denies that this is what actually happens at least in the first instance. Constructionism argues that we are born into a world of culture, where objects have already been given meaning. This cultural understanding can be seen as 'pre-empting the task of meaning making' so that for the most part 'we simply do not do what constructivism describes us doing' (Crotty, 1998, p. 79). Phenomenology, by contrast, asks us to disregard our preconceived cultural understanding of phenomena and asks us to make understanding directly. Within a research perspective, phenomenology is considered to be a study of peoples' subjective and everyday experiences. To gather such data the researcher must undertake in-depth interviews with people who have 'directly experienced the phenomena of interest; that is they have lived experience'

(Patton, 2002, p.104). Methodologically techniques such as unstructured interviews, in which open ended questions or no questions at all are utilised to prevent observer bias. Methodological bias, within the data analysis, is overcome by inviting others (including the subjects) to be involved in the identification of themes to support the researchers claim that they are genuinely found in the data.

4.5.4 Symbolic Interactionism

According to Crotty (1998, p.71) symbolic interactionism and phenomenology 'contrast sharply with each other' in their attitude to 'towards culture as our inherited meaning system'. Symbolic interactionism treats culture as the 'meaningful matrix that guides our lives', whereas phenomenology treats culture with a 'good measure of caution. While culture offers us an entry point to a 'comprehensive set of meanings', it 'shuts off an abundant font of untapped significance' (Crotty, 1998, p.71)

According to Grey (2009, p.22) Symbolic Interactionism grew in the late 30's out of the work of American pragmatist John Dewey and the social psychologist George Herbert Mead. The central theme of symbolic interactionism is that 'human interaction with the world is mediated through the process of meaning making and interpretation' (Grey, 2009, p.22).

The essential tenets of symbolic interactionism according to Grey (2009, p.22) are as follows:

- People interpret the meaning of objects and actions in the world and then act upon those interpretations
- Meanings arise from the process of social interaction

- Meanings are handled in, and modified by an interactive process used by people in dealing with phenomena

According to Crotty (1998, p. 72) in order to do them justice these tenets need to be set against a backdrop of pragmatist philosophy. The characteristic idea of pragmatist philosophy is that of 'efficacy in practical application' (Crotty, 1998, p.74) or in other words we accept the theory that will be of greater practical use.

According to Mead our 'very personhood is attributed to social forces that shape us and our behaviour' (Crotty, 1998, p.74). In developing his theory Mead outlined a developmental process that children pass through as they master 'socialisation and internalisation skills' (Manning and Smith, 2010, p.45). During this process children pass through a critical passage from 'play stage to game stage' during which they take on the role of 'significant others' such as parents that have a 'concrete existence' for them (Manning and Smith, 2010, p.45). Later within the game stage of development, where they understand the different roles played by members of the group they begin to play the role of 'generalised others' that exist only in 'abstract form' (Manning and Smith, 2010, p.45). In doing so children's activities become 'structured by rules and bounded in space and time thereby preparing them for the practical constraints of adult life' (Manning and Smith, 2010, p.45). A central premise of symbolic interactionism thus becomes that of 'putting oneself in the place of others' (Crotty, 1998, p.75). Methodologically researchers have to study a subject's 'actions, objects and society from the perspective of the subject themselves' (Grey, 2009, p.22).

According to Crotty (1998, p.75)

> *'This role taking is an **interaction**. It is a* symbolic interaction*, for it is only possible because of the 'significant symbols' that is language and other symbolic tools – that we humans share and through which we communicate. Only through dialogue can one become aware of the perceptions, feelings and attitudes of others and interpret their meanings and intent'*

In practice this means 'entering the field setting and observing first-hand what is happening' (Grey, 2009, p.22). From this perspective symbolic interactionism has embraced the methodology developed within cultural anthropology that is ethnography.

4.6 Methodology

According to Crotty (1998, p.7) research methodology describes our 'strategy or plan of action, which shapes our choice and use of particular methods and links them to desired outcomes'. Within this framework the methodology of choice for the author has been highlighted as ethnography. Within this context research methods are described as 'concrete techniques or procedures we plan to use in order to gather and analyse our data' (Crotty, 1998, p.6). Included within the methods section are highlighted techniques utilised by the author to undertake this research such as participant observation, unobtrusive data collection methods, interviews, and focus groups. Included in the methodology section within Crotty's (1998) framework however is the term 'case study' which appears to be interchangeable with the term ethnography in a great deal of the literature. The following review will then consider this dichotomy in more detail, within the context of the researcher's position as an employee past and present of both of the organisations under investigation.

4.6.1 Ethnography

In their study investigating the social consequences of educating young people who have endured chronic illness White, Drew and Hay (2009, p.21) initially consider ethnographic and case study methodologies to be ‘interchangeable’. A brief review of the literature (Cresswell, 2009; Bryman, 2008) reveals that the definitions of ethnography and case study share many similarities and it is understandable that confusion can easily arise.

According to Cresswell (2009, p.13) case studies are a strategy of inquiry, in which the researcher ‘explores in depth a program, event, activity, process or one or more individuals’. Cases are then ‘bounded by time and activity, and researchers collect detailed information using a variety of data collection procedures over a sustained period of time’. The term case study is sometimes extended to include the study of just ‘two or three cases for comparative purposes’ (Bryman, 2008, p.402).

Reflecting on Guba and Lincolns (2005) paradigmatic positions (White, Drew and Hay, 2009, p.21) consider case study research ‘to belong to the conservative end of the qualitative continuum in post positivism, while ethnography spans the ‘critical theory’, ‘constructivism’ and ‘participatory paradigms’. This post positivist interpretation is supported by Stake (2005, p.460) who considers case study to belong to part of ‘scientific methodology’. Case study analysis is only differentiated from other qualitative strategies by ‘bounding the case’ (Stake, 1978, p.7), or ‘conceptualising the object of study’ (Stake, 2005, p.461).

Alternatively ethnographic research is a strategy of inquiry, in which the researcher studies an intact cultural group in a natural setting over a prolonged period of time by collecting, primarily observational and interview data.

By definition an ethnographer is then someone who 'immerses him or herself in a group for an extended period of time, observing behaviour, listening to what is said in conversation, both between others and with the fieldworker and asking questions' (Bryman, 2008, p.402). The term ethnography has an additional meaning over and above 'participant observation' in that it 'frequently refers to both a methodology of research and the written product of that research' (Bryman, 2008, p.402). According to White, Drew and Hay (2009, p.22) 'sociologists who use qualitative techniques such as ethnography or participant observation, which are time consuming and cannot be delegated to research assistants, almost invariably choose the case study method'.

By focusing predominantly on the 'presence of the researcher in the research', rather on the 'material and information provided by the participants' (White, Drew and Hay, 2009, p.24) the author considers his methodological stance to be more akin to an ethnographic than case study approach. In no small part this is considered appropriate in his role as Haematology manager at both Organisation X and Organisation Y and latterly as Head of Diagnostics at Organisation Y. In that respect 'immersion' (Greenhalgh and Swinglehurst, 2011, p.2) within a social setting for an extended period of time is inevitable. Opportunities to engage with staff and observe the cultural aspects of each organisation are considered to be a fundamental part of the managerial role. From this privileged position the author also had unlimited access to current and historical documentation relating to both organisations.

In addition the author also developed a relationship with the private sector 'partner' of both Organisation X and Organisation Y. The primary supplier provides both organisations with the majority of equipment and reagents to undertake the pathology tests as part of a managed service plan (MSP). This long-term relationship (10 years) is a novel undertaking, which is dependent on transferring a degree of organisational risk from user to supplier in return for tax exemptions. Practically speaking the relationship is by necessity much closer than that normally observed between designer/supplier and user than has previously been investigated within the literature. As a result this factor allows a unique opportunity to investigate the supplier/user interface.

Within the UK, NHS Pathology services have been that target of a prolonged modernisation programme since the late 90's (Great Britain. Department of Health, 2002; 2004). This drive to influence organisational structure, culture and technology gained further momentum following the review of pathology services by Lord Carter in 2006 (Great Britain. Department of Health, 2006) and the subsequent review in 2008 (Great Britain. Department of Health, 2008). In his role as a founder member of formerly the TeesPath and latterly the N.E. Path pathology modernisation groups and Chair of the N.E. Path Haematology modernisation subgroup, the author also had access to data and has played a participant/observer role within the modernisation programme. This unique position was used within this research to reveal the influence of such a programme on the two independent primary organisations Organisation X and Organisation Y under investigation.

4.6.2 Multi-site Ethnography

The methodological stance adopted by the researcher has by necessity been influenced by changing job roles and the transfer from one organisation to another. This in itself is not considered to be a detrimental factor but has necessitated a modification of the methodological stance taken. As a consequence this transfer of job roles has resulted in a change from a single to multi-site ethnographical study. For the full time researcher, access to such an environment and length of time available to fully integrate into a new culture is considered a down side of the ethnographic approach. Obviously being an employee within both of these organisations overcomes these difficulties. In addition one of the drawbacks of being a part time student is the length of time required to complete the process. However in this case the additional amount of time required was utilised to good effect in providing a more detailed and richer picture of the proceedings.

In his study of foreign correspondents across the globe, Hannerz (2003) reviews the advantages and disadvantages of multi sit ethnography. Hannerz (2003, p.206) argues that the term ‘multilocal’ (multi-site) projects is a little misleading in that they ‘commonly draw on some problem or some formulation of a topic which is significantly translocal, not to be confined within a single place’. He goes on to state that ‘the sites are connected with one another in such ways that the relationships between them are as important for this formulation as the relationships within them; the fields are not some mere collection of local units’ (Hannerz, 2003, p.206). This is certainly the case within this study, as Organisation X and Organisation Y are two of eight Foundations Trusts (FT) within N.E. Path. More significantly within this configuration the two Trusts are geographically situated in close proximity. As a result patient care pathways overlap and patient referrals between the two organisations for specialist care including cancer services and major spinal trauma are common. In addition to these connections the private sector supplier also links Organisation X and Organisation Y by providing the majority of technology and reagents used within both organisations. Strategies to follow these 'connections, associations, and putative relationships' are considered 'at the very heart of designing multi-sited ethnographic research' (Marcus, 1995, p.97).

Hannerz (2003, p.208) states that one of the criticisms of multi-site ethnography is the question of 'depth and breadth of relationship' in that this form of research may be viewed as a dilution of the original long-term anthropological studies. For the reasons highlighted above, in that the researcher is both an employee and part-time student, these factors do not appear to be as relevant within the context of this research.

The issue of 'site temporality' Hannerz (2003, p.209) or 'time limitations' (Freidberg, 2001, p.263) is more cause for concern. The last five years have seen unprecedented changes within the NHS from political reform to economic crisis. This study is, however, concerned with the performativity of reality in order to gain an understanding of the reconfiguration taking place, rather than a direct comparison of the two organisations. The affordances and constraints imposed on each organisation will be assessed in light of these external pressures. Other logistical considerations such as 'access, funding and other resources available' (Freidberg, 2001, p.263) were not a limitation during this study.

4.7 Methods

Rather than produce a definitive definition of ethnography, applicable to all contexts, Atkinson and Hamersley (2007, p.3) focus on what ethnographers actually do as highlighted by the following passage:

'In terms of data collection, ethnography usually involves the researcher participating overtly or covertly, in people's daily lives for an extended period of time, watching what happens, listening to what is said, and/or asking questions through informal and formal interview, collecting documents and artefacts – in fact, gathering whatever data are available to throw light on issues that are the emerging focus of inquiry'.

The principal methods for collecting primary data for qualitative research are shown in Table 11 below:

Table 11. Techniques Used for Qualitative Data Collection adapted from Thietart et al. (2001).

TECHNIQUE	METHOD EMPLOYED
Observation	Participant observation Non-participant observation
Unobtrusive methods	Physical traces Primary archives Secondary archives Simple observations Behaviour records
Interviewing	Individual interviews Group interviews

Within this research all three techniques have been utilised. Primary data was collected via participant observation of the organisations under investigation, subsidised by open access to primary and secondary archives. Within this context primary archives were considered to consist of documents available to the researcher/manager within the organisational domain, such as business cases, tender documentation, contractual information and the minutes of meetings. Secondary archives within this environment were considered to consist of digital e-mail, received personally by the researcher manager. In addition a number of semi-structured interviews were undertaken when necessary to gain an insight into the wider issues concerning pathology managers in the region and our third party colleagues from the primary supplier identified during the course of this research.

The following section provides a critical review of the techniques highlighted above and including a review of template analysis utilised to analyse the primary data from the interviews.

4.7.1 Observation

According to Gray (2009, p.396) observation is not simply a question of ‘looking at something and noting down the facts’ it is a complex combination of sensation (sight, sound, touch, smell, and even taste) and perception. Observation thus involves the ‘systematic viewing of people’s actions and the recording, analysis and interpretation of their behaviour’ (Gray, 2009, p.397). One of the benefits and consequently drawbacks of the technique, however, is that it is open to individual interpretation of meaning. On the plus side however observation techniques allow the researcher to get ‘beyond people’s opinions and self-interpretations of their attitudes and behaviours, towards an elevation of their actions in practice’ (Gray, 2009, p.397), attributes deemed essential for this study.

The primary downside of the technique is however interpretation of what is observed which may be influenced by the ‘mental constructs of the researcher including (values, motivations, prejudices and emotions)’ (Grey, 2009, p.397).

A second concern is that, stationed among those being observed, the researcher may begin to actually influence events. It this case the researcher is employed to manage the organisations under investigation and in a position of authority is paid to influence results, which poses a methodological challenge.

In addition, it has to be considered that the mere presence of a senior manager in a working environment may influence the behaviour of staff.

Within this context it could be argued that the primary role of the researcher in the work place is that of manager rather than researcher. Indeed most of the members of staff are ignorant or indifferent to the manager's involvement within research and so as far as possible the observations have been undertaken in as natural an environment as possible.

A third methodological concern is that although observational data is often rich in evidence it can be difficult to extract themes and concepts. In this instance observational data will be supported by the information provided by other unobtrusive methods.

4.7.2 Overt v covert observation

According to Gray (2009, p.397) overt observation 'is where those being observed are aware that the observation is taking place'. Conversely covert observation is where those being studied are unaware of this taking place. Despite its negative connotations and ethical issues, the author considered his observational style as being predominately covert. At no time did the author hide the fact that he was undertaking organisational research and indeed was willing to discuss the issue with any interested party at any time. Principally these observations were made simply as part of everyday working life. Methodologically field notes were kept to a minimum, and more use was made of physical traces including organisational documents, e-mail transcripts, notes of meetings and focus groups. A predominantly covert observational style was considered necessary to limit bias within this study, as people are more likely to change their behaviour when being observed. Grey (2009, p.398) also raises the point that particularly with regard to e-mail, all of these messages are stored within organisations and depending on information governance laws can be scrutinised. In this respect ‘covert observation is now part of our everyday lives’. From an ethical perspective, the use of e-mail as a source of secondary data was kept to an absolute minimum during the course of this research and was only used to highlight specific personal perspectives from clinical colleagues and union representatives, on the strategic direction of Organisation Y.

4.7.3 Participant v structured observation

According to Grey (2009, p.399) participant observation, as opposed to structured observation, is more closely aligned to the ethnographic methodology. Structured observation is more closely linked to quantitative techniques where for example task frequency would be monitored and recorded. Participant observation on the other hand is concerned with the ‘generation of data through observing and listening to people in their natural setting, and to discover their social meanings and interpretations of their own experiences’ (Grey, 2009, p.399). Part of this process is the ‘reporting of the researchers own experiences, feelings, fears, anxieties and social meaning, when engaged with people in the field’ (Grey, 2009, p.399). The researcher thus becomes a part of the community under investigation and so begins to understand their situation by immersion in the research setting.

The key benefit of participant observation is that it provides ‘unusual opportunities for data collection’ including ‘access to events, groups or key decision makers, that are otherwise inaccessible to a study’ (Yin, 2009, p.112).

A major challenge of the participant observational methodology, however, is keeping a balance between 'insider and outsider status' (Grey, 2009, p.400) and hence the potential to 'bias' the findings (Yin, 2009, p.112). To gain a deep understanding of the environment, it is considered essential that the researcher gets both 'physically and emotionally close to the study group', while at the same time maintaining a 'professional' distance (Grey, 2009, p.400). The second problem related to participant observation was that the participant observer is likely to follow a 'commonly known phenomenon and become a supporter of the group or organisation under study' (Yin, 2009, p.113). Thirdly 'the participant role may require too much attention relative to the observer role' (Yin, 2009, p.113).

Grey (2009, p.401) identifies a subdivision of participant observation, that of the 'practitioner researcher', as being someone who 'undertakes research within and often on behalf of their organisation' and this would appear to be the perspective of the researcher in this study. The negative side of the practitioner/researcher is the fact they may be 'imbued with the organisations ethos and attitudes and so have difficulty adopting fresh perspectives and approaches' (Grey, 2009, p.402).

One popular practitioner/researcher approach is ethnographic (Hartmann, Fischer and Haymaker, 2009; Tacchi, Slater and Hearn, 2003) or practitioner/participatory action research (Patten, Mitton and Donaldson, 2006; Blomqvist et al. 2010; Beringer and Fletcher, 2011; Gatenby and Humphries, 2000). Although initially considered by the author one important characteristic of action research is that 'practitioners and researchers work closely together throughout the whole research process' (Hartmann, Fischer and Haymaker, 2008, p.60). Thus researchers and participants systematically work together in cycles of ‘looking, thinking and acting’ (Day, Higgins and Koch, 2009, p.13). In doing so ‘it is possible to gather and simultaneously verify knowledge’ as an ‘iterative cycle’ of observation, problem identification, solution development and implementation akin to Demming’s Plan, Do, Study, Act cycle (Orsini, 2013).

This form of reciprocal learning was not formally undertaken during the course of this study, although the views and perceptions of staff were considered fundamentally important and these views were utilised to influence the overall direction of the organisation.

4.7.4 Fieldnotes

According to Mason (2002, p.98) recording observational data in the form of fieldnotes can vary considerably in use depending on methodological and theoretical orientation. Fieldnotes can, therefore, be considered to be ‘raw data’ from which excerpts can be used for inclusion within the formal written account. Conversely fieldnotes can also be considered more as ‘developmental devices’ for formulating your understanding of your setting. Practically the production of fieldnotes can take many forms ranging from mental notes, useful when it is ‘inappropriate to be seen taking notes, to ‘jotted notes on scraps of paper’ (Bryman, 2008, p.420) all the way through to the production and use of a formal ‘observational protocol’ (Cresswell, 2009, p. 181). The route adopted by the researcher was a mixture of all three techniques. Although not adopting a formal observational protocol, note taking was structured into the production of a daily diary to record operational detail, supported by more detailed informal note production during key conversations and meetings, in addition to the formal minutes produced as a result of these discussions. A representative example of fieldnotes produced during the course of this research is provided in appendix 3.

4.8 Unobtrusive qualitative methods of data collection

As stated above the use of unobtrusive data collection methods was also considered a rich source of data collection within this study. Unobtrusive data collection methods include 'documentary evidence, physical evidence and archival analysis' (Gray, 2009, p.425). Included within this source of data were internal organisational records such as documents, business cases, tender information, contractual agreements, and minutes of meetings. In addition digital e-mail archives were also utilised as a source of information. The ethical issues of doing so have already been considered earlier in this chapter.

Gathering information from documents does raise a number of concerns, they may be 'more or less detailed and comprehensive, they may not be authentic and genuine and hence unreliable', and they may be 'so numerous or so badly flied as to not be readily available' (Mason, 2002, p.110). In addition the process of reading, understanding, translating and interpreting documents adds a further dimension of 'construction and reflexivity' (Mason, 2002, p.110). Within this study the researcher had full access to the majority of formal organisational documentation; as such the authenticity of the documentation cannot be questioned.

4.9 Interviews

Participant/observation and analysis of unobtrusive data was supported in this study by interviews. Primarily these interviews took place to gain a deeper insight into areas where participant observation was not possible. As stated by Mason (2002, p.66) the decision to choose qualitative interviewing can be taken because 'the data you want may not be feasibly available in any other form'. Hence 'asking people for their accounts, talking and listening to them and so on, is the only way to generate the data that you want' (Mason, 2002, p.66). Interviews are considered the best way to capture 'exploratory data' involving the examination of 'feelings or attitudes' as well as a means to 'probe for more detailed responses' (Grey, 2009, p.370).

Firstly interviews took place with representative senior laboratory managers from constitutive organisations within the N.E. Path modernisation group. The aim of which was to gain an understanding of their perception of the technological affordances and constraints of LSPA. When these interviews took place during early 2008 the concept of LSPA systems was still very much in its infancy and very few laboratories within the UK had undertaken a full-scale implementation. These interviews, therefore, took place to gain an understanding of the perceptions and intentions of managers together with an understanding of the reasoning behind their decision making process to adopt wide scale automation or not as the case may be.

Interviews were also undertaken with colleagues working for the primary supplier of LSPA, in order to gain an understanding of the design process and the implications of how these design decisions were incorporated into the technology. In addition, questions were also asked to investigate the designers' intentions with regard to the potential to change user organisations structures and working practices.

According to Grey (2009, p.367) an interview is a 'conversation between people in which one person has the role of researcher'. During this conversation the interviewer has to pose questions in either a structured, semi structured or unstructured format, capture the resulting data and if appropriate pose new questions. Grey (2009, p.371) identifies several different types of interview, which may be divided into five categories as follows:

• Structured interviews

• Semi structured interviews

• Non-directive interviews

• Focused interviews

• Informal conversational interviews

The approach taken by the author was principally that of semi-structured interview. This is considered appropriate when the researcher has a ‘list of issues and questions to be covered but may not deal with all of them depending on the direction the interview takes’ (Grey, 2009, p.373). Conversely during this form of interviewing additional questions may be posed that were not considered or anticipated at the beginning of the process. During this process the advice of Bryman (2008, p.447) was taken in that ‘the main ingredient of interviewing is listening and being attentive, without being too intrusive’.

Bryman (2008, p.448) also suggested that the questioning should begin with an initial open-ended question aimed at setting the tone of the interview and engaging the interviewee. Following this initial introduction more probing ‘intermediate questions’ (Bryman, 2008, p. 448) were used to highlight specific areas of interest to the researcher, while at the same time allowing the respondents room to highlight other issues or concerns.

4.9.1 Focus groups

In addition to the one to one interviews highlighted above a number of pathology staff focus groups were also held during the course of the research. Bryman (2008, p.473) states that ‘a focus group is a particular form of interview that involves more than one, usually at least four interviewees'. The primary use of a focus group is accordingly used to discuss a 'certain issue as members of a group, rather than simply as individuals' (Bryman, 2008, p.473). The benefit of a focus group therefore is to 'understand how people respond to other's views and build up a view out of the interactions that takes place within the group' (Bryman, 2008, p.473). In all cases these focus groups were conducted as part of the researcher's role as senior manager within the organisation. Other senior managers selected participants independently to provide a representative cross section of the working population. Within this context the researcher acted as a facilitator or moderator and this role was communicated to all staff involved in the process independently of the research programme. Data was collected during these sessions on flip chart and incorporated into workshop notes that were subsequently distributed and ratified by all members of staff involved before being formally distributed to all staff for information and as a means of stimulating discussion.

Bryman (2008, p.488) highlights some methodological difficulties with focus groups, in that principally they can be difficult to manage and control. For example many staff wishing to speaking at once, or indeed reticent to speak at all. As an experienced senior manager this was not considered to be a drawback. However Bryman (2008, p.489) adds that a related drawback involves participants working in a focus group 'being more prone to express culturally expected views rather than during individual interviews'. During this research the distillation of numerous culturally different perspectives ratified by the whole group for public consumption was considered a means of overcoming such difficulties.

4.9.2 Sampling

The requisite number of respondents required, in relation to any qualitative research programme, is a cause for concern. According to Bryman (2008, p.458) often 'convenience samples' are taken because of restrictions placed on the researcher. Ideally it is recommended that 'purposive sampling' should be conducted, which is defined as a 'strategic attempt to establish a good correspondence between research questions and sampling'. Grey (2009, p.376) gives more practical advice, referencing Arksey and Knight (1999) who offer two fundamental principles for selecting a given sample number as follows:

- Try to select a sample that allows for a subject to be viewed from all relevant perspectives.
- Keep increasing the sample size, or sub-samples that represent different perspectives, until no new viewpoints are collected.

The managerial group included representatives from all of the acute NHS Trusts in the North East of England and hence representatives from the entire N.E. Path modernisation group. This group included sites that had already undertaken large-scale automation projects, those that were involved in the tendering process or considering entering into a tender process and a site that had rejected the concept. In order to view the subject from all relevant perspectives, the interview sample included representatives from a laboratory in Scotland who had specifically introduced the primary supplier technology (at this stage no one in the North East had purchased equipment from this manufacturer). Table 12 represents an overview of the managerial interview sample.

Table 12. Managerial interview sample

Position	Organisation	Transcript code
Pathology manager	A	M1
Haematology manager	B	M2
Haematology manager	C	M3
Pathology manager	D	M4
Haematology manager	E	M5
Pathology manager	F	M6
Pathology manager	G	M7
Pathology manager	H	M8
Biochemistry manager	I	M9
Pathology manager	J	M10

The individual questions prepared for the managerial group, together with the rationale behind the specific line of questioning are highlighted in table 12 below:

Table 13 Rationale behind the questions used for semi-structured interviews undertaken with Pathology managers:

Question	Rationale
Why did you decide to invest in full laboratory automation?	The aim of this question was to broadly investigate the perceptions and intentions of managers considering or having already invested in large scale Pathology automation. It was envisaged that this question would highlight affordances and constraints of the technology from a managerial perspective.
If not have you considered full laboratory automation?	This question was aimed at managers who were not considering investing in wide-scale pathology automation and it was envisaged that this line of questioning would highlight some of the principal constraints of introducing such a system
Have you chosen to employ one tracking system for Biochemistry/haematology or a separate system for both?	LSPA are generally purchased as either a combined system for Biochemistry and haematology or as two discreet production lines for each discipline. This question therefore explored the rationale for choosing either or system.
What influenced that decision?	As above
Do you intend to run the system 24 hours a day? If not why not?	Early discussions with manufacturers suggested that to achieve maximum efficiency from the automated platforms the technology should be running 24/7. This question therefore explored managerial intentions and the associated implications for staff operating the system primarily during non-core hours
Do you think that the system will change the staffing structure within the department? and if so how?	This generic question aimed to identify the perceived or actual effect of the automated platform on staffing structures across the entire 24/7 period
Have you or do you intend to change the way you process samples as a result of the track?	This question aimed to investigate if perceived or identified constraints imposed by the technology would affect the traditional way samples moved through the laboratory. Especially important here was changes to the transportation and reception of specimens i.e. pre analytical processes.
Have you considered the effect the system will have on staff from a work life balance perspective?	This broad question was introduced to capture any staff related affordances and constraints not identified in the above line of questioning.
Have you explored any particular type of methodology to help with this change process such as ‘Lean’	During the tendering process at Organisation X all of the manufacturers proposed to use lean manufacturing principles to aid the change process and reconfigure the laboratory in preparation for the technology. This questioned aimed to identify if these principles or other methodologies were being considered. Particularly in relation to the issue of homogeneity of working practice across sites

The interview candidates selected to represent designers within the primary supplier proved to be more difficult because at this stage of the development many of the original designers had move on to other jobs, a factor which must be considered as an unavoidable limitation.

The sample was therefore restricted to a senior marketing executive who had for many years been influential in the design of the equipment. In addition two members of the UK implementation team and two members of the Health Care Solutions (HCS) team were also interviewed. The implementation team as the name suggests are involved in the implementation of the technology across the UK. This group were seen as experts on the material aspects of the equipment and highly influential in feeding back design affordances and constraints. The HCS team are utilised after implementation and are primarily involved in the organisational redesign of laboratories, utilising primarily lean manufacturing techniques. The HCS group are also intimately involved with the equipment in-practice and undertake annual ‘health checks’ on every customer site. The health checks involve analysis of technical data stored within the technology itself and on laboratory computer systems within organisational practices. This group were an important source of information with regard to affordances and constraints of the equipment and experts on the ‘work-arounds’ staff utilise within laboratories to and over-come difficulties. Table 14 gives a summary of the primary supplier managerial interview sample.

Table 14. Primary supplier managerial interview sample

Position	Organisation	Transcript code
Senior Marketing Executive	Primary Supplier	S1
HCS representative	Primary Supplier	S2
HCS representative	Primary Supplier	S3
Implementation team representative	Primary Supplier	S4
Implementation team representative	Primary Supplier	S5

The individual questions together with the rationale behind the questions delivered colleagues from the primary supplier are highlighted in table 15 below:

Table 15. Questions and rationale behind the questions used for semi-structured interviews undertaken with colleagues from the primary equipment supplier to Organisation X and Organisation Y.

Question	Rationale
What do you think was the primary supplier vision for LSPA	This is a generic opening question aimed at gaining an understanding of the intentions of the suppliers/designers
Do you think the primary supplier expected LSPA to change working practice in the laboratory? If so how?	This question aims to gain an wider understanding of the intentions of designers to change operational practices in the laboratory
Do you think that the primary supplier expected the introduction of LSPA to influence the staffing structure within the laboratory? If so how?	This question aims to investigate if The primary technology supplier purposefully intended to influence the staffing structure.
What grade of staff do you think that the primary supplier expected to be using this equipment?	Staff grade within the context of the UK NHS refers to Agenda for Change hierarchical banding. The intention here was to explore the distribution of qualified Biomedical Scientists and 'non-qualified' support staff.
What specific design features do you think facilitate these changes?	Self-explanatory
Do you think that the primary supplier expected the introduction of LSPA to facilitate the integration of departments Haematology and Biochemistry for example?	This question is designed to investigate if it is a design intention to integrate departments.
Why do you think that laboratories in the UK on the whole have resisted an integrated approach?	Self-explanatory
Do staff on site routinely modify/customise/not use certain functions within LSPA?	Self-explanatory
Is the process review team unique to the UK?	This question aimed to investigate the role of the HCS team within the UK and the use of predominantly lean methodology on the homogeneity of working practice.

4.9.3 Pilot Interviews

In order to refine both sets of questions the researcher undertook a brief pilot study engaging two senior biomedical scientists to review the questions and suggest amendments. This process allowed the researcher to streamline the questions making them more readily accessible to the sample group. Practically speaking a full-scale pilot study would have been a useful addition to the protocol. However because of the very exclusive sample under investigation a meaningful trial was not possible or at least practicable in this case.

4.9.4 Validity

Within the context of this research, validity is considered to represent that an 'instrument must measure what it is intended to measure' (Grey, 2009, p.375). With regard to semi-structured interviews Grey (2009, p.375) suggests that the issue of validity can be addressed by 'attempting to ensure that the question content directly concentrates on the research objectives'.

In this respect an attempt was made to keep the questions relevant and to the point. The researcher was acutely aware of the time constraints placed on senior managers in both the public and private sector. At the same time it was also considered vital to build up a rapport with the interviewee and time to allow them scope to fully express their views.

Within this context the reliability and influence of interviewer bias is considered to be a major limitation of interview methodology (Yin, 2009; Grey, 2009). According to Grey (2009, p.376) the only way to counterbalance the issue of methodological bias in this instance is to try and standardise the behaviour of both the interview schedule and interviewer as much as is practically possible.

4.9.5 Transcription

All of the interviews were audio recorded and transcribed in their entirety. The researcher transcribed all of the managerial interviews but received some professional help transcribing all of the primary supplier interviews. There was an initial concern that some of the depth and richness contained within the primary supplier data would be lost through professional transcription. Practically however each interview was reviewed and modified by the researcher allowing full immersion within the text. Due to the relatively small number of primary supplier interviews the professional help was thus considered a massive advantage, allowing the study to progress at a reasonable rate while the researcher was in full time employment. According to Silverman (2011, p.366) ‘the reliability of the interpretation of transcripts may be gravely weakened by a failure to transcribe apparently trivial, but often crucial pauses and overlaps’. Within this work the ‘yes’ and more importantly the ‘mm’s’ were included, to mark the point when the interviewee’s were ‘taking up information’ (Silverman, 2011, p.367). This was particularly evident in the interviews undertaken with the staff from the primary equipment supplier organisation. The researcher considered that the interview questions would be challenging but it became apparent that in some cases the primary supplier staff were keen to elucidate that the views they were giving were their own and not necessarily the corporate line.

4.9.6 Data analysis

According to Mason (2002, p.147) the ‘would be’ qualitative researcher is faced with a bewildering number of techniques to try and make sense of an accumulation of seemingly unconnected data produced during the course of the research. In order to make some sense of this vast array of information it is recommended that the data be organised either physically or into virtual archives, which make up a system, which is consistent across the whole data set. In order to refine the data produced from the interview transcriptions the researcher decided to use template analysis (Scott, Davidson and Edwards, 2002; King, 1998; Crabtree and Miller, 1999) to firstly code and then manipulate the data with the overall aim of revealing connections, within and across the breadth of the text. This decision was in part a pragmatic one in that the researcher had previously utilised this technique to good effect, during a previous period of research.

4.9.7 Template Analysis

The Template analysis approach involved 'coding a large volume of text so that segments about an identified topic (the codes) could be assembled in one place to complete the interpretive process' (Waring and Wainwright, 2008, p.86).

Working in the field of health and sociology King (1998) argues that template analysis 'can be seen as occupying the middle ground between Content Analysis (Weber, 1990), where codes are all predetermined and their distribution is analysed statistically, and Grounded Theory (Glaser and Strauss, 1967), where there is no *a priori* definition of codes' (King, 1998, p.120). Crabtree and Miller (1999, p.167) state that template analysis is an 'intermediate approach when some initial codes are refined and modified during the analysis process'.

According to King (1998, p.119) a code is 'a label attached to a section of text to index it as relating to a theme or issue in the data which the researcher has identified as important'. In this case the researcher took the advice of Crabtree and Miller (1999, p.168) when they advocate the 'initial hand coding of hard copy versions of transcripts with a pencil or highlighter' in order to achieve a degree of 'immersion/crystallisation' within the text.

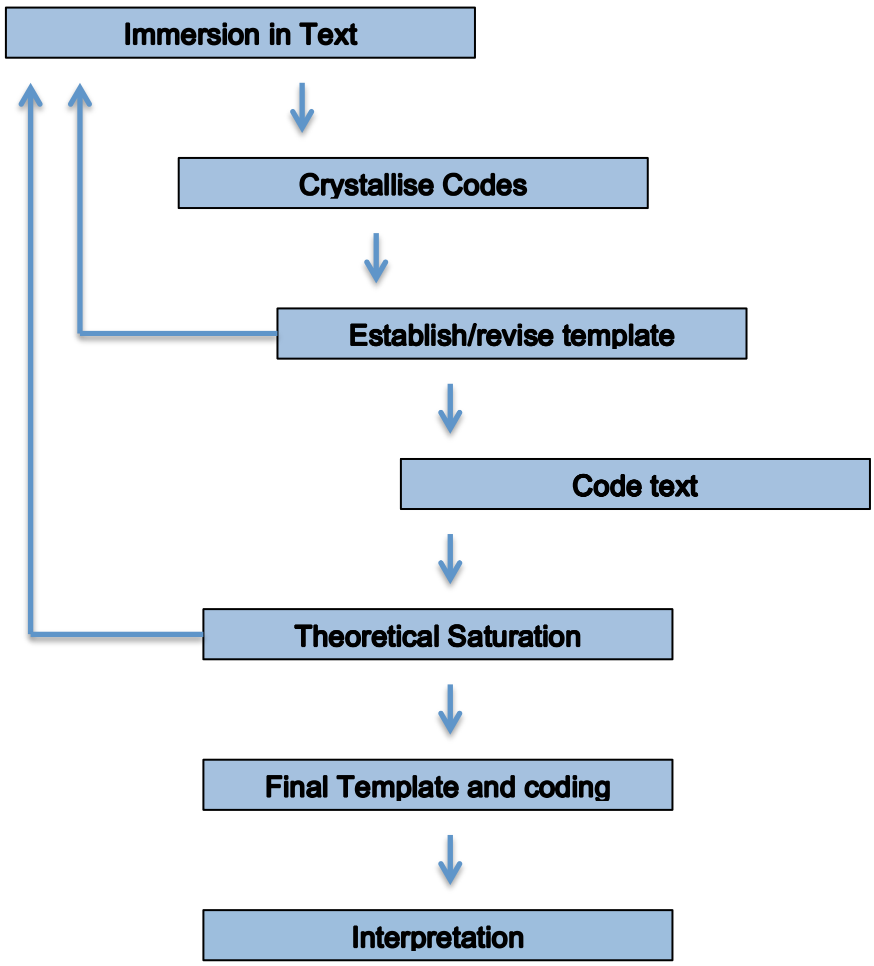
It is usual in template analysis for codes to be 'organised hierarchically, with groups of similar codes clustered together to produce more general higher order codes' (King, 1998, p.120). The distribution of the codes within and across transcripts can help draw attention to aspects of the data, which warrant further examination. The frequency and distribution of codes is used as a means of making 'connections' within the text (Crabtree and Miller, 1999, p.169). King (1998, p.130) however issues a word of warning about counting the codes in that 'there is a danger in such a procedure that the researcher will make the false assumption that differences in frequencies will automatically correspond to meaningful differences within or between transcripts'. The other major concern when undertaking template analysis is that it can often leave the researcher 'feeling unsure about the analytical decisions he or she has to make, resulting in templates, which are too complex to be manageable' (King, 1998, p. 133).

According Waring and Wainwright (2008, p.86) the complete analysis process is considered to involve the following:

- Creating a code manual/coding system
- Hand or computer coding the text
- Sorting segments to get all similar text in one place
- Reading the segments and making connections that are subsequently corroborated and legitimised

The code and template development cycle is represented in Figure 5.

Figure 5. The Code and Template Development Cycle adapted from Scott, Davidson and Edwards (2002)



After many reviews of the interview text, codes emerged from the data as recurring themes based predominantly on the recurring themes of material affordances, constraints and intentions. The templates produced as a result of this research from both the managerial and supplier interviews can be seen in Appendix 4, and 5.

4.10 The researcher and ethical issues

During the course of this research the overarching imperative was to avoid causing harm to any individual or organisation. According to Stake (2005, p.459) ‘the value of the best research is not likely to outweigh injury to a person exposed’. Exposure in this case could lead to ‘embarrassment, loss of standing, employment or self-esteem which it was obviously essential to avoid’ (Stake, 2005, p.459). Within the context of this work, the researcher was acutely aware of the organisational as well as personal ethical considerations and accordingly ethical approval was requested and granted from the University of Northumbria (Appendix 1). From an NHS perspective, this research was considered to fall under the realm of service improvement; as such ethical approval was not required under NHS research governance arrangements (Appendix 2).

Prior to the interview process the researcher obtained informed consent from each interviewee (Appendix 4). The content of the form together with a study information sheet (Appendix 5) was discussed at the beginning of each interview and permission was requested to audio record the conversation. All interview candidates were given the option of reviewing the transcript, although only one person actually took up this offer. During the data analysis all sample group were given anonymity by the use of an alphabetical code. Throughout the text organisational anonymity has been maintained by the use of pseudonyms (Primary Supplier, Organisation X etc.) and redaction of organisational logo’s etc. where necessary.

4.11 Summary of Research Design

This chapter has presented the philosophical position, underpinning this research, together with a structured framework to support the methodological approach. In order to explore the relationship between the social and the technical elements observed within two pathology laboratories in the north east of England the researcher a sociomaterial perspective was adopted which rejects the notion that the world is composed of individuals, with separately attributable properties. Instead the world is considered to be an entanglement of sociomaterial practices enacted in day-to-day life. In order to investigate this ontological perspective, a social constructionist epistemology has been adopted where meaning is developed through human interaction engagement and interpretation. From this interpretivist perspective, symbolic interactionism has been utilised to explore the shared understanding, feelings and attitudes of staff working in this environment. The methodology of choice for this form of investigation has then been highlighted as multi-site ethnography, due the researcher's role as employee in both organisations. From this stand point a multi-method approach has been taken, involving participant observation undertaken during the course of routine working life together, supported by extensive unobtrusive data collection. In addition semi-structured interviews and focus groups interviews have utilised to gather information unavailable via participant observation. This data includes the views of both a number of pathology managers, involved in the purchase of LSPA, together with those of the primary supplier of technology to both the sites under investigation.

Chapter 5 Bridging the gap between design and use

5.0 Introduction

According to Leonardi and Barley (2008, p.166) with a few notable exceptions (Orlikowski, 1996; Thomas, 1994; Leonardi, 2007) 'students of technology have traditionally focused on the effects before or after a technology is introduced into a work setting'. A failure to bridge the gap between design and use therefore, makes it difficult to address technology studies 'most pressing issues'; do suppliers of technology intend to shape the working practices and social structures of users and if they do, how do they embody these intentions in their designs? (Leonardi and Barley, 2008, p.166). According to Leonardi and Barley (2008, p.167) 'studying on-going cycles of design, use and modification provides a strong strategy for untangling the relationship between agency, the material and the social, because it can treat both the social and the material as emerging, evolving and entwined'. From this perspective the question is not whether technologies change through use, but rather, what processes lead to change and what determines the pace of change (Leonardi and Barley, 2008, p.167). The aim of this chapter is then to investigate the design intentions of a primary supplier of LSPA. This research will then consider the impact of this relatively 'fixed function technology' (Orlikowski, 1996, p.90) in practice, across organisational boundaries.

5.1 Primary supplier overview

The primary supplier of diagnostic equipment to both Organisation X and Organisation Y is a subsidiary of Europe's largest based electronics and electrical engineering company. It is organised into five main divisions: Industry, Energy, Healthcare, Infrastructure & Cities and Financial Services. Globally the Healthcare division alone 'employs approximately 51,000 staff', with a revenue turnover worth '€13.6 billion and profits of approximately €1.8 in fiscal 2012' (Primary Supplier Healthcare Sector Global Website, 2012). The provision of laboratory diagnostics forms a subsidiary of the Healthcare division. According to the primary supplier website the Diagnostics division is described as follows:

> *'a global leader in in-vitro diagnostics providing healthcare professionals in hospital, reference and physician office laboratories and point of care settings with the vital information required to accurately diagnose, treat and monitor patients' (*Primary Supplier Healthcare Sector Global Website, 2012)

The Diagnostics division aims to provide 'innovative products and complete solutions as well as service and consulting in the healthcare industry' (Primary Supplier Healthcare Sector Global Website, 2012).

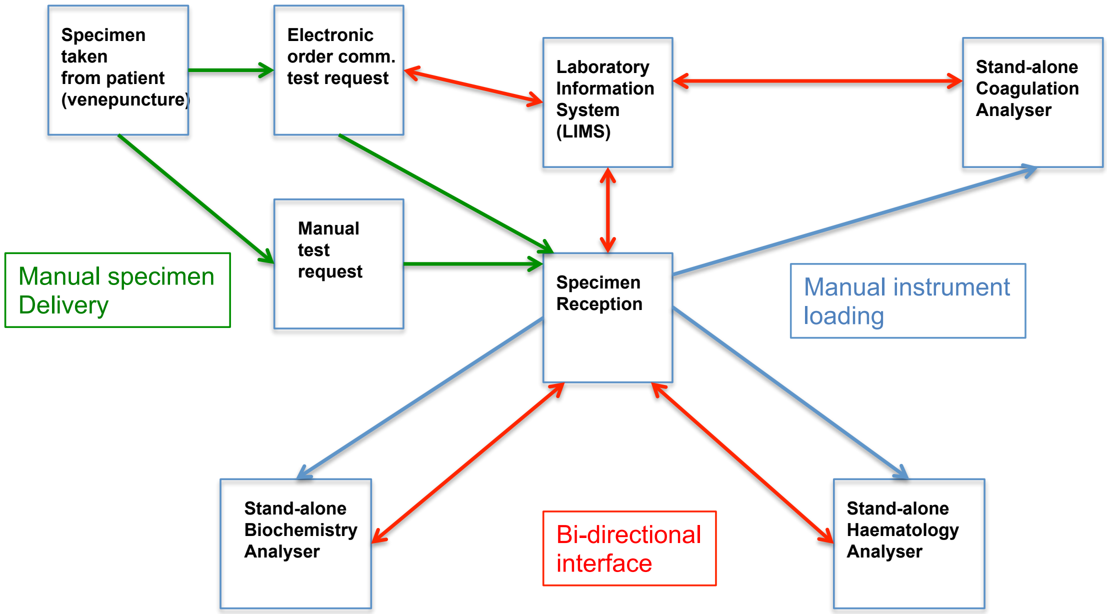
In order to achieve these aims their approach to users/customers is described as follows:

> *'Our systematic, customer-centred approach to product development is constantly shaped and strengthened by listening to customers and understanding their needs. Working closely with laboratories, clinicians and hospital administrators, we create forward-thinking products and solutions that are shaping and transforming diagnostics – improving clinical outcomes and, ultimately improving patient care'* (Primary Supplier Healthcare Sector Global Website, 2012).

5.2 Traditional pathology automation

The traditional orientation of pathology automation can be seen in Figure 6 below to which the following sections of this section will refer:

Figure 6. Traditional orientation of pathology automation



5.2.1 Specimen taking and preparation

Within a modern NHS laboratory the pathology process for biochemistry and haematology testing begins with a blood sample being taken from the patient (venepuncture) into an evacuated colour coded tube. Following venepuncture the requesting clinicians have two options to physically order pathology tests. The first option is to complete a hand written request form detailing the patient demographics (name, hospital number, age, sex, clinical condition) and the required pathology tests. Alternatively clinicians within ward areas and GP surgeries can enter the above patient demographic and test request information electronically via an integrated order communication (order comm) system. The order comm middleware will then relay the patient and test information directly into the referring laboratories Laboratory Information System (LIMS). Upon completion of the test request both the form and the specimen are placed in a sealable plastic bag and transported to the laboratory.

5.2.2 Specimen reception

Upon receipt into the laboratory specimen reception area the plastic bag holding the specimen and the attached test request form are manually separated. A manual check is then undertaken as a safety precaution to ensure the patient demographics on both the specimen and the form correspond.

5.2.3 Data entry

If the specimens are received via the handwritten request route a unique barcode is then manually attached to both the specimen and form before the patient details and test request information is manually entered into the LIMS.

If specimens are received via the order comm route the test request and demographic information will have already been entered onto the LIMS. In addition a unique set of barcodes will also have been produced in the clinical area. It is therefore the responsibility of clinical staff to ensure that the appropriate barcode is attached to both specimen and form. Once an order comm request has been received in the laboratory a member of staff is still required to manually scan the barcode into the LIMS to register the specimen as received.

Following data entry the test request information will be relayed via a bidirectional interface from the LIMS to the individual stand-alone analysers in preparation for analysis.

5.2.4 Analysis

Following specimen reception and data entry the specimens are then manually transported and physically loaded onto individual stand-alone analysers. In order to ensure that the correct specimen is placed on the appropriate analyser the individual specimens are colour coded according to pathology discipline. Hence specimens requiring haematology analysis should be drawn into a purple-topped tube, biochemistry a yellow-topped tube etc. Failure to manually feed the appropriate specimen to the appropriate analyser would have dire consequences for result quality. Once the specimen has been placed onto the analyser the instrumentation automatically undertakes the associated test. Following analysis the test result is automatically linked to the corresponding patient demographics using the unique barcode number as a central point of reference. The completed test request information is subsequently transferred back to the LIMS via the bidirectional interface.

5.2.5 Result validation

The LIMS or associated instrument middleware is capable of holding a number 'normal' and 'alert' reference ranges with which the patient test result generated during the analysis phase is electronically compared. Patient results deemed 'normal' by the automated system, on the basis of sex, age and other user definable criteria, are automatically validated from the system and the results are made available within the clinical areas. In essence 'normal' specimens undergoing this process, which have had tests ordered electronically will have minimal human intervention within a laboratory and may never be viewed by a biomedical scientist.

Any results deemed to be outside of designated 'normal ranges' will be held back for scrutiny by a qualified biomedical scientist, who will make a knowledge based judgement to request further tests, pass the results on to a consultant member of staff for clinical comment or in extreme cases inform the requesting clinician directly for immediate action.

Once the validation step has been undertaken completed test results are then either sent electronically back to the requesting clinician via the order comm system or printed hard copy reports are issued for inclusion within the patient notes.

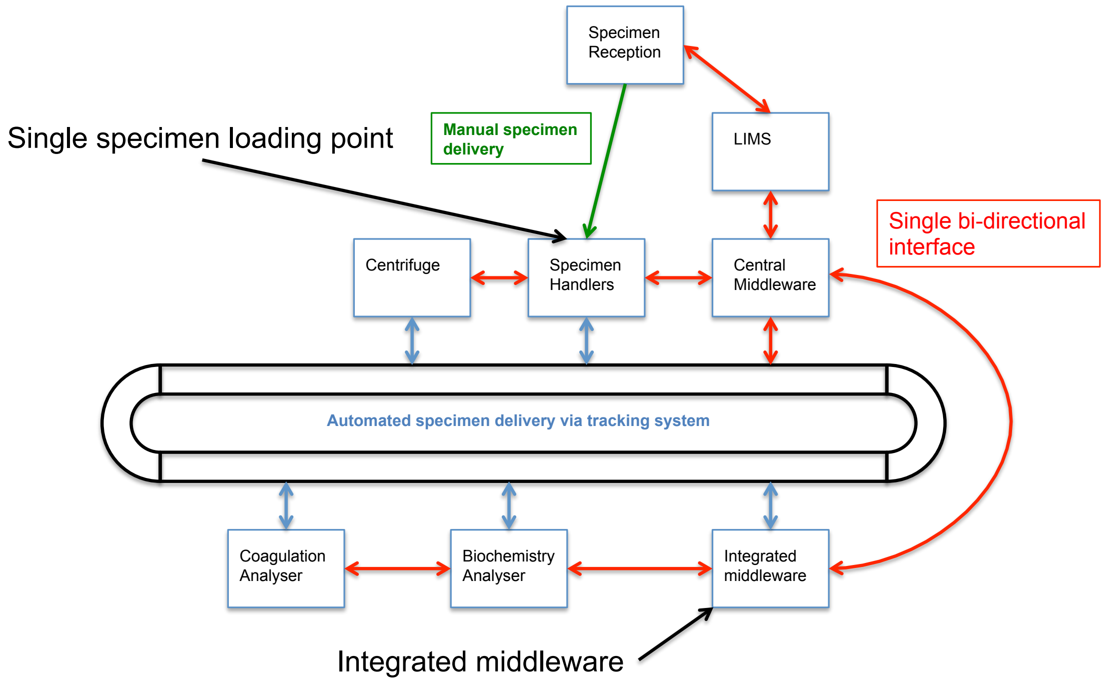
In Figure 7 a number of different stand-alone analysers have been identified representing individual departments within pathology in this case haematology, coagulation and biochemistry. In reality these individual departments may be physically separate areas within the laboratory. The manual loading of a stand-alone instrument is illustrated below in photograph 1

Photograph 1. Manual loading of a standalone pathology analyser

5.3 Large Scale Pathology Automation (LSPA)

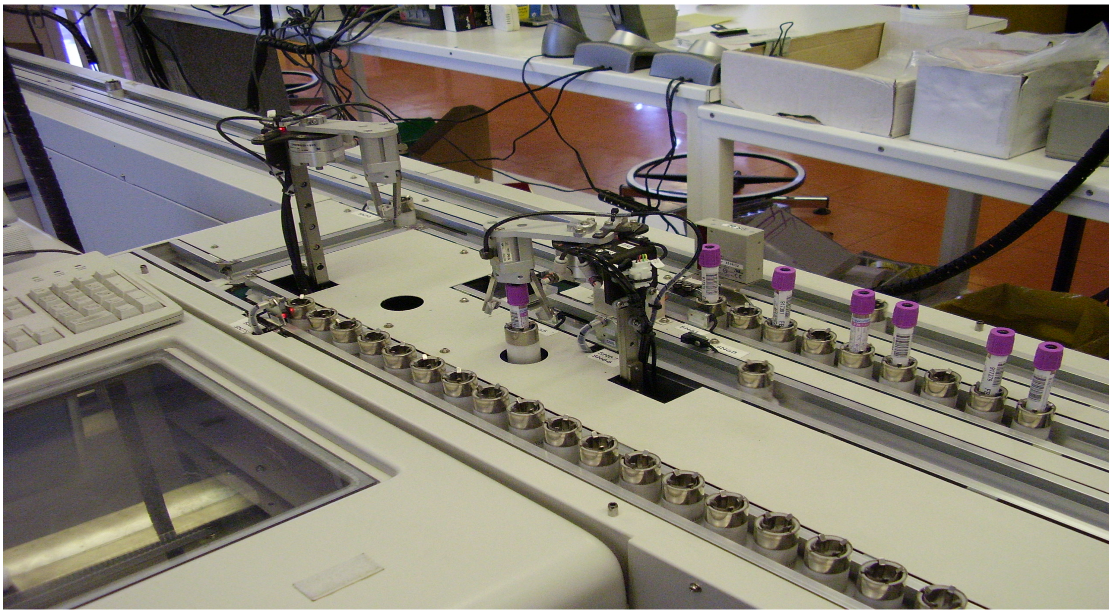
Over the past ten years the traditional working arrangements of pathology laboratories have been challenged with the introduction of LSPA, Illustrated in figure 7 below:

Figure 7. Large Scale Pathology Automation (LSPA)



Within this arrangement the instrumentation used to perform the analysis phase remains largely unchanged from the stand-alone instruments identified within the traditional process. The fundamental difference between the LSPA arrangement and the traditional working patterns revolves around the provision of an automated tracking system designed to deliver the specimens to the analysers, which are now physically attached to a track. The track itself is constructed from a number of interlinked pucks, which transport the individual specimens to the analysers as highlighted in the photograph 2 below:

Photograph 2. LSPA tracking system with associated robotics

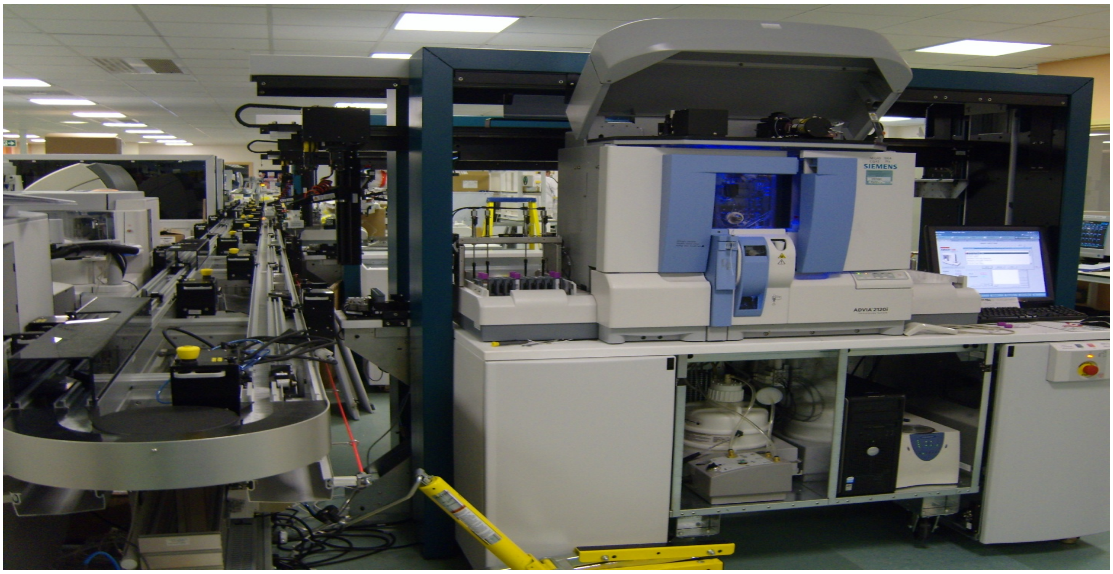


The LSPA system also includes a number of additional pieces of technology aimed at automating the whole pathology process. These include specimen handlers, which robotically load specimens on to the track and subsequently remove and store the specimens following analysis. The provision of on-line centrifuges also removes another previously manual step.

The entire LSPA is controlled by an integrated middleware system linked via bi-directional interface to the LIMS. This system of integrated middleware can be utilised as a central point of control for the entire system.

The LSPA system including specimen transportation track and associated instrumentation is illustrated in photograph 3:

Photograph 3. LSPA technology within Organisation Y



5.4 Bridging the gap between design and use

The remainder of this chapter is dedicated to investigating the design intentions of the suppliers of LSPA, with regard to changes of organisational structure and working practice. In order to investigate exactly how much influence the primary supplier wished to have on user organisations, a series of semi-structured interviews were undertaken with a member of the design team based in the United States of America (USA), two members of the UK implementation team and two members of the primary supplier UK HCS consultancy team. The results of these interviews were subsequently analysed using template analysis, the output of which can be seen in Appendix 6.

5.4.1 Results of interviews with primary supplier

The first question in the series of interviews with the primary supplier staff related to the perceived 'vision' for the automated tracking system. This initial question was designed to be an open-ended introduction to begin the conversation and elicited some thought provoking answers as follows:

'From my perspective the 'vision' for the automated technology was to try and incorporate as many of the disciplines and tests within a central laboratory into a common platform. From the company perspective there is more business selling the whole range of tests, but the spin off for the lab it that there is an opportunity for a single process, a single work flow type methodology throughout the lab and the thought of a systemic approach, laboratories could become more productive and potentially slicker' (S4)

'I have always thought that the 'vision' was "it's one tube", "it's bloods" and so therefore why should that blood be taken to three different places to book in the same patient, to have their demographics entered into three separate places and then be routed through three separate sets of analysers. I would have thought that that was part of the rationale for it' (S2).

'It's obviously about revenue and I think it's a matter of filling a lab with our kit such that we can put as much of our revenue generated analysers in there as possible. It's a matter of supplying a package to the customer be it immuno, chemistry and possibly haematology as well, to get as much of our kit in the room as we can to generate as much revenue as possible'. (S5).

Importantly within the context of this research it must be borne in mind that the primary automation supplier was external to the user organisation and as such the decision to offer a 'multi-disciplinary' option, whereby the user organisation would purchase the majority of biochemistry and haematology equipment from one primary supplier, was linked to income generation.

With regard to the design intentions of the primary supplier only Manager 1 was in a position to review the history of the technology.

*'Let's step back so I can tell you how we got involved with it. The system was actually initially developed by Dr X for (*a competitor*) laboratories commercial lab chain about 10-12 years ago. You can imagine the large commercial labs trying to get efficiencies in operation, labour and error reduction would be something of large interest to them' (S1).*

The tracking element of the LSPA system was then not a bespoke piece of equipment; the primary supplier essentially modified a system that was already in commercial operation as highlighted below:

> *'So they went out and looked at available technology, they didn't want to reinvent the wheel, but they looked at things that existed and basically tried to take components that they saw out there and adapt them to the application. The actual track portion of the technology is the direct movement of a track used in a pharmaceutical bottle filling line. So it wasn't like it was created for the purpose, it was actually adapted and that is one of the reasons that the technology if you look at it is probably more robust looking of all the laboratory systems because of the generation it came from. If you look at some of the newer ones they are not as hefty/heavy looking because "form follows function" sort of thing, they were built specifically to do the job, rather than take an application' (S1).*

The ability to reinvent technology, originally designed for a different albeit similar process, is reminiscent of Lévi-Strauss (1968) 'bricoleur'. The possibilities contained within an object's materiality remain limited by 'the particular history of each piece and by those features, which are already determined by the use for which it was originally intended or the modifications it has undergone for other purposes,' (Lévi-Strauss, 1968).

According to the primary suppliers, the design of the technology was driven by the needs of the users who were asking for tools to overcome reduced staffing levels including a 'failure to train or recruit biomedical scientists' (S1, S3, S4), and as a positive reaction to an aging workforce (S1, S3, S4).

> *'They were very concerned about the lack of new medical technologists* (biomedical scientists)*. As you know, especially in the US, the particular field that supplies people to the laboratory is primarily a group of people who are medical technologists that were four year degreed laboratory trained people. The average age of them is now like 55, the demographic is generally female and basically they are not being replaced. Then you got to the point where a lot of these medical technology schools closed and basically the industry was being asked for more tools to help and one of the ways we could help them was basically to provide automation to reduce the labour' (S1).*

From the above quotation it is interesting to note that an apparent reduction in the number of trainee biomedical scientists appears to be a global issue, being as relevant within the USA as it does within the UK as highlighted below:

> *'one thing they saw as an opportunity was the apparent lack of people, skill set and new people coming through. In some of our sites, I'm thinking of 15 years ago I was talking to people where they have got eight people in the pathology department and five of them were due to retire in eighteen months. They could not fill any of the trainee posts because of financial reasons. They were posing the question to us 15 years ago and saying OK, we now have 8 people today, tomorrow we will have 5 people, and how will we do the same amount of work with 5 people. I think automation was rising as the laboratories were reporting this problem with staffing levels and pressure on staffing levels (S4).*

The introduction of LSPA was then seen as a means of overcoming a shortage of trained scientific staff. In addition this technological response to staff shortages was also seen as a means of reducing human error:

> *'Issue number two as you know lean processes, efficiencies are constantly been applied to laboratories today and one of the key aspects is error reduction. Laboratories output is basically results to the physicians and they want them to be error free. As you know any time a human touches anything it's an opportunity to make a mistake. So automation also tries to remove the human touches as much as possible and replace it with fail safe automation systems' (S1).*

From a strategic perspective a member of staff from the primary supplier HCS team stated that within the UK the technology was designed to facilitate the development of integrated pathology networks'.

> *'My understanding and kind of perception of it is that they could see that there were different levels of integration, consolidation and the development of networks. 'From feedback that they had that there was a need for some equipment, or some level of automation on the equipment to be able to help the labs or to help the trusts. You could see through this, their vision of becoming more integrated and consolidated' (S2).*

Within this context the introduction of LSPA can be seen as a direct response to the UK Government's drive to modernise pathology services. The concept of a network is centred on the ability to form a large integrated 'hub' laboratory and it can be argued that the introduction of a large LSPA system sends a positive signal to competitors.

5.4.2 Changes to working practice

Template analysis highlighted that all five respondents believed that the introduction of LSPA was designed to change working practice, within a laboratory environment. Four out of the five respondents suggested that the technology was expected to consolidate working practice and facilitate the introduction of multi-disciplinary working. In this context the term multi-disciplinary working has both social and technical connotations. From a social perspective multi-disciplinary working refers to the ability of laboratory staff to have the knowledge and skills to operate in multiple pathology disciplines for example biochemistry and haematology, as traditionally staff are trained to work in either/or but not both. In this respect the term multi-disciplinary is analogous to the sociotechnical concept of 'multi-functional' as opposed to 'multi-tasking' (Niepce and Molleman, 1998, p.266) as highlighted below.

> *'if you adopt a different working practice, if you change the way you are structured, if you breakdown some boundaries, this common tool can be driven by a haematologist, a chemist or by somebody suitably trained as a track master (S4).*

Secondly the introduction of LSPA was seen as a means of being able to physically bring disparate departments together. Within this context, multi-disciplinary working refers to integrating the individual pathology disciplines into one physical area. Traditionally the stand-alone technology utilised within haematology and biochemistry may not have even been in the same room. The introduction of the LSPA system requires the previously stand-alone instrumentation to be physically attached to the track.

In this respect multi-disciplinary working refers to a physical breakdown of traditional departmental boundaries with regard to space and time.

> *'it's bringing different disciplines into the one footprint therefore people aren't having to deal with stand-alone instrumentation. You know so it's much easier to look after, when it's run out, it's easier to have an overview of what is happening, so you don't need as much handling time on individual instrumentation. The fact that it has the central loader and the centrifugation on- line, it's having less and different process steps that have been consolidated into the one automated platform' (S2).*

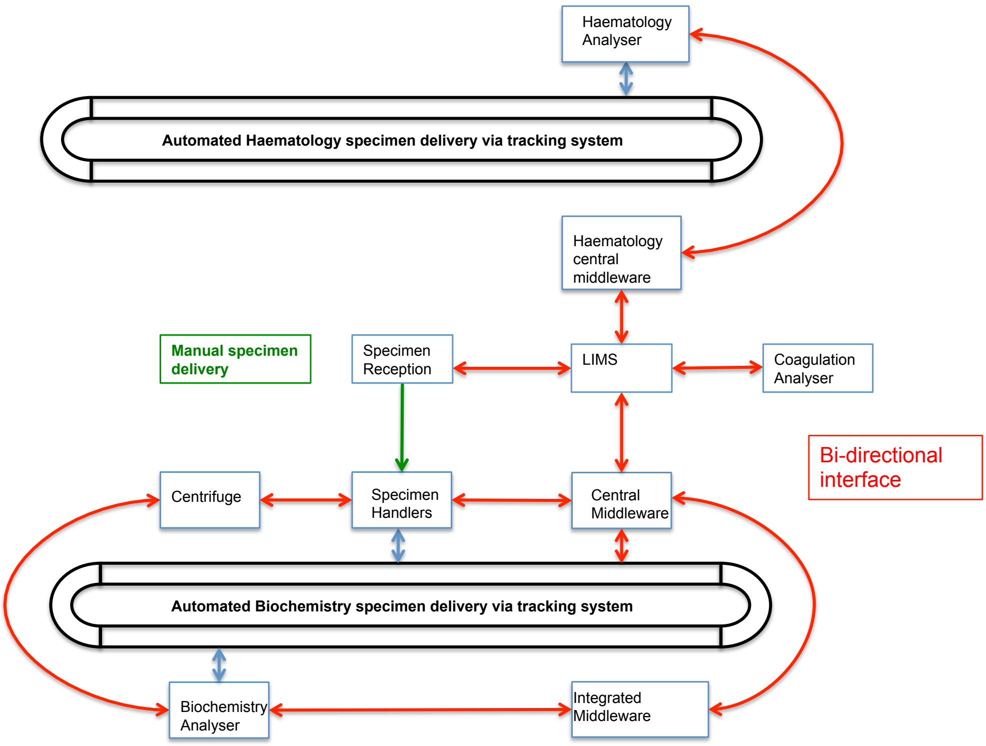
> *'It was the intention up front to provide the ability to have multi-disciplinary (technology) which we do have' I would say between 15 and 20% of our LSPA systems have all the disciplines on chemistry, immunoassay, haematology, haemostasis etc.' (S1).*

5.4.3 Design feature 1 Single pathology platform

It is clear from the above research that the designers of the LSPA system intended their system to function as a single automated platform, designed to incorporate analysers from as many pathology disciplines as possible. The design was developed to link disparate disciplines in order to facilitate 'multi-disciplinary working'. As a result of this design decision, staff that had previously worked in isolation would be physically brought together and encouraged to work within the material confines of the single platform. Accordingly the design features of the instrumentation facilitate multi-disciplinary working. As Figure 8 illustrates the tracking platform provided by the primary supplier is a single continuous production line, with individual analysers physically linked to the track. Following manual specimen delivery onto the specimen handlers the entire pathology process is in theory fully automated. Specimens are transported to individual pieces of equipment via the automated tracking system and robotically loaded and unloaded from the individual analysers before subsequent automated storage. The materiality of the tracking system itself is designed to constrain the user, removing previously manual steps with an automated process. Human agency within this system is reduced to essentially loading and unloading specimen racks following analysis, together with subsequent validation of abnormal results.

The single-track option produced by the primary supplier within the context of this research is not the only automated pathology system on the market. Instead of a single track, designed to bring together disparate pathology disciplines, other designers have developed a dual tracking system, which separates the disciplines of haematology and biochemistry into two individual platforms. As stated above by manager 1 only 15-20% of customers worldwide have actually purchased the single-track option incorporating both haematology and biochemistry. It can only be assumed that the remaining 80% of primary supplier customers have purchased a hybrid dual track system, which would include the primary supplier option as illustrated in Figure 8 minus the haematology equipment. As the primary supplier described within the context of this research does not produce a dedicated haematology track it can only be assumed that the remaining 80% of customers have purchased the haematology track from a competitor.

Figure 8. Primary supplier dual track option



One of the primary questions to be answered as part of this research was to investigate whether the intentions of designers of technology were subsequently realised in practice. With regard to the introduction of multi-disciplinary working the answer must be a resounding no, as 80% of customers have opted for a dual platform.

The decision to select a single or dual track system has obviously got to be made prior to implementation. As such this represents a bridging activity between the designer and the user or more accurately the designer and the manager of the user. In this respect this research has highlighted a limitation of previous work into the effects of technology on organisational design. Previous work has focused either on the development and design of technology or on the effects during or after use as two separate entities, the bridging activity of selection of technology has been given little if any attention. The reasoning behind the decision to select a single or dual track system will be explored in more detail within the next Chapter (6) following a series of semi-structured interviews with pathology managers involved in the procurement of LSPA.

With regard to the perceptions of the primary supplier, however resistance to adopt a single platform and hence introduce multi-disciplinary, appears to be culturally driven. Following the implementation of a fully automated tracking system in one large laboratory, manager 1 stated that the supplier had been asked to remove the system:

> *‘people that like instruments gravitated towards chemistry and people who didn’t like instruments gravitated to disciplines like haematology or micro* (Microbiology) *or blood bank’. ‘We have placed (LSPA) within Haematology and we have had the lab come back to us two years later and say take it off. Why? Not because it didn’t work, it’s because they still could not break down the walls between the divisions’ (S1)*

> *‘the haematology pathologist was standing there while it was going in and she is looking at me with evil eyes and said “you see this line on the floor Mr A”. “I never ever want to see that track cross this line”. You know what’s in there now seven years later? The* (LSPA) is *in there and the same lady came up here and is looking me in the eye and says “I can no longer afford to ignore the labour savings provided by automation, I give up!” (S1).*

> *‘you know I am a medical technologist and I remember getting trained and I remember going through Haematology and going through Chemistry and all the different disciplines and the Haematology people saying look if you want to play that numbers game, if you want no art to your work, go down to Chemistry. If you really wanted to be a scientist and look down microscopes, you stay down here with us’ (S1).*

> *‘I think in most instances it’s down to the strength of personality and characters within the laboratory and that tends to be down to difference in thought process. It’s where haematology want to go in one direction and immunochemistry in another and they don’t see much in the way of common ground’ (S4).*

5.4.4 Changes to staffing structure

All five managers also stated that the introduction of LSPA was expected to bring about changes to staffing structure. Although all five managers indicated that the LSPA system would require less human intervention it was argued that politically more qualified and hence more expensive biomedical scientist staff would still be employed in pathology but encouraged to do other more specialised work in the laboratory.

> *'One of the things we as vendors say is well it will reduce your labour force and the staff hate to hear that, but it is a net result of getting the automation. Most laboratories took a much more benign approach where they would allow them to lose people by attrition, allow them to reassign people to perhaps doing esoteric tests that they were sending out. But it does have a direct effect on the amount of labour that you need to run your laboratory' (S1).*

Within this context 'esoteric tests' are viewed as specialist tests that require a high degree of scientific skill or knowledge to perform. Within a routine pathology laboratory these complex tests would normally be referred to a centre of excellence specialising in this work.

> *'I think there is also a political side of this where people don't want to lose staff in the lab, so the managers don't want to lose staff either, so they move everyone around a bit and find work for them to do basically. You can run a lab now with two people essentially with* LSPA, *you can do the job. You couldn't in the past. So yeah on the face of it you look and think yeah we can get rid of people, but it's certainly not in our interest to do that and obviously the management of the lab don't want to do that. Whether that is going to change over the next 2 or 3 years who knows but thus far I don't see that' (S4).*

The two managers from the HCS team indicated strongly that the intentions of the primary supplier to influence staffing structure were driven from the market. In addition the HCS team were actually involved in producing a model, which could be used to predict staff numbers and grades.

'Yes I would say originally that all thoughts around staffing would be from the market, and again it's the rationale behind us trying to formalise some kind of ideal staffing model, because it's what we are constantly asked to provide. Historically a manufacturing organisation would not have been willing to put their neck on the line to say that this is your configuration, therefore you only need x number of staff, because there is so many things that are going to influence it. If we are not in control of all the processes, what we are going to have to do is say' "this is from our experience" and from "the data that we have collected", an idea of how the LSPA should be staffed' (S2).

In response to this line of questioning the researcher then asked a subsidiary question; do you think it's fair to say then that managers of organisations are actually asking you to define what their staffing structure should be?

'Well yes because they are actually asking us to give them solutions as to how to provide the service in total. We have tenders that ask, "give us all the information we need" to give them a solution. It's a case of well what do you think we should have, not all the time but we do get that' (S2).

The primary supplier's intention to be directly involved in the staffing structures of user organisations was subsequently confirmed by the second member of the HCS team.

'What we want to get is to a position where we would be able to suggest or recommend even, how many people should be running the operation and indeed what type of operator should be deployed to the task. It's quite a complex issue and will change and differ from site to site depending on the structure of the organisation. Certainly we could expect that given that a lot of the sample handling is automated, the question is do we need to deploy highly qualified staff to do that or is it a more support worker activity. That's where we need to gather information, gather what's happening in different laboratories and try to understand what best practice is so that we can at least recommend, with again some data to back up our claim' (S3).

Template analysis (Appendix 6) also made a significant connection in that all five managers indicated that changes to staffing structure would be brought about by a change in skill mix, substituting qualified biomedical scientist staff with support workers. Two design features in particular, a central loading point for specimens and a system of integrated middleware are considered to embody these intentions within the design of the technology.

5.4.5 Design feature 2 Central loading point.

Template analysis (Appendix 6) highlighted that all five managers considered a central loading point for specimens and integrated middleware as fundamental to their intentions to bring about changes to staffing structure. In the traditional pathology process, highlighted earlier in this chapter, stand-alone instruments physically separated in a laboratory, were manually loaded prior to analysis. As can be seen in Figure 8 within the LSPA technology this was no longer the case. Following specimen reception and data input large racks of specimens, some of which required haematology analysis and some of which required biochemistry testing, would all be placed together on the specimen handler via the central loading point. Following this step the rest of the process including specimen transport is fully automated. The central loading point on the data handlers therefore represents in theory the only time a human should have contact with the system apart from instrument reagent replacement, quality control procedures and routine maintenance, as highlighted below:

> *'Basically the whole process of loading samples turn into a production line', 'basically someone can come along with a tray of samples put it on the draw and press go. Without diminishing the role too much that really is pretty straightforward, anyone can do that' (S5).*
>
> *'the key thing is the fact that you have a central point of loading that basically has a track attached that will distribute samples to all of these analytical devises' (S1).*
>
> *'Yeah if you had a workload requirement to have three chemistry analysers then you would have to have some kind of process where you would know which samples to load onto which analysers and be able to route them accordingly'.* The LSPA *'takes all those manual steps out because it will intelligently route to the appropriate analysers based on the test information given' and 'the samples are all being loaded in the one place rather than being front loaded', so you are having haematology staff working in the same place as biochemistry staff' (S2).*

'I think maybe it's the demarcation in the past that equipment was qualified staff, front end manual sampling was none qualified staff but the fact that the actual activity is sample handling and it's using equipment, people can be trained to push the buttons and understand the logic, it's not rocket science' (S3)

In addition, to the affordances offered by the design of the central loading point, it was also acknowledged that the materiality of the automated tracking system created issues with regard to the processing of urgent specimens (within a laboratory environment these specimens are frequently termed (STAT) derived from the Latin word *statim* meaning immediately). The automated tracking system was designed to process large volumes of specimens in a standardised way through the central loading point. Within this system it is difficult therefore to prioritise urgent specimens as highlighted by manager 1.

'it is a little bit more difficult to manage STAT processing because they LSPA *are designed for productivity' there are some opportunities within the track that basically get STATS optimised and we just launched a new version of LSPA software which has a whole new layer of software features which attempt to improve STAT turnaround time, so we are constantly looking at how we can tweak these things' (S1).*

5.4.6 Design feature 3 Integrated middleware

All five members of the primary supplier team also identified integrated middleware as an essential design feature to affect staffing structure.

During the review of automation in the traditional pathology laboratory described above the majority of standalone instruments would have been acquired on an ad-hoc basis. Standalone instruments purchased from different manufacturers over a number of years would then appear physically different. In the rapidly changing world of biomedical science even instruments purchased from a single supplier could be radically different with each new generation. Advances in hardware and software utilised to operate the instrumentation often matched the technological advances, thus compounding the physical differences. In addition during this research the primary supplier could not offer the full remit of technology required to integrate haematology, biochemistry and blood coagulation. In particular the coagulation analysers had to be outsourced from a third party manufacturer.

The primary supplier integrated middleware was then designed to consolidate these disparate systems as highlighted below:

> *'You have to remember that the primary supplier portfolio right now is really instruments around three different major companies, so they don't look and feel the same when you look at the user interfaces, just because of where they came from. You can remove that objection by using the common middleware for review and edit'. (S1).*

This common user interface was then seen as overcoming the cultural resistance between departments by providing a single point of contact for the user. Although the technology itself appeared physically different, each piece of kit could be controlled from a single interface.

> *'I think generically middleware and the IT component around automation and consolidation of results is absolutely critical, that has to be truly functional to manage all the data flow' 'it's automating even the thought process that the operator may have had to go through in the past' (S3).*

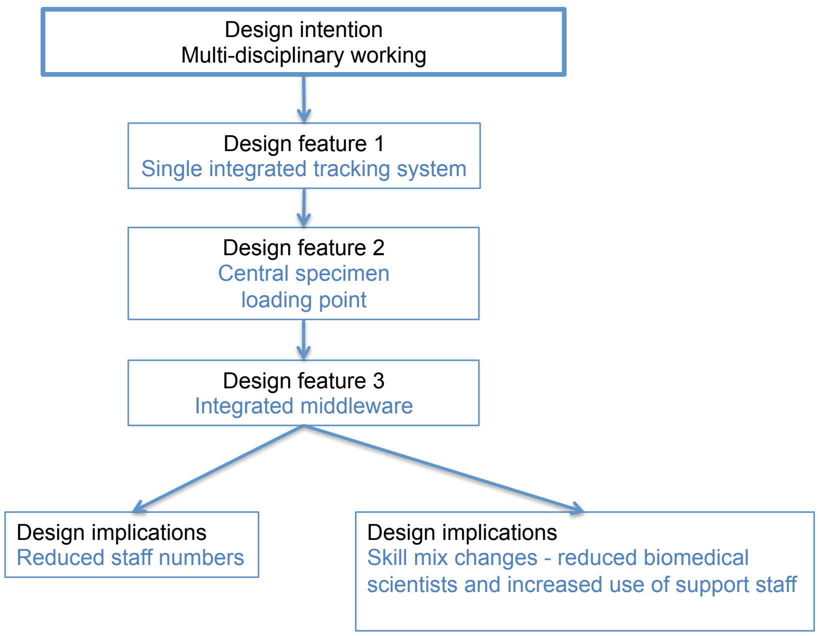
The individual required to co-ordinate single user interface is commonly referred to as the 'track-master'. According to one of the implementation staff there is an opportunity to 'take advantage of the technology' by utilising support staff. The reasoning behind this perception is stated as follows:

> *'we have actually seen incidences where the person identified to undertake the track-master role was a medical laboratory aid* (support staff) *because they can be directed, no preconceptions, that is what we want you to do to the best of your ability, that actually worked very well' (S5).*

The design of the technology including the standardisation of the common user interface was therefore seen as a means of facilitating a change in skill mix from scientific to support staff, and as a means of overcoming the cultural preconceptions of the latter group of staff.

The design intention to facilitate multi-disciplinary working can then be seen to be composed of three distinct elements. From a technical perspective the introduction of a single integrated platform combining instrumentation from multiple disciplines, a single point for specimen loading and a single interface, was designed to physically integrate disparate departments. As a result of these physical design features, it was envisaged that the system would require greatly reduced human intervention and facilitate a skill mix change. In practice this would result in a reduced requirement for biomedical scientist staff whilst conversely increasing the need for scientific support staff. The design intentions and associated features can be seen below in Figure 9:

Figure 9. Design intentions, features and associated implications of the introduction of LSPA



5.5 Structural changes within the primary supplier organisation

During this line of questioning another unexpected high-level code was generated via template analysis (Appendix 6) termed the effect on supplier organisation staffing structure. Within this context the actual make-up of the implementation and HCS teams appeared to be shifting from a purely engineering base to include ex-laboratory staff:

> *'There are four of us for implementing and installations. We also have another member of ex-laboratory staff who came in primarily as a trainer, to train the customer onsite after we had finished installation, but he does a lot more on the application side now. So he will work with the customer on the middleware side of things to tie together the IT system' (S5)*

> *'We make sure that the ex laboratory member of staff is working with the customers absolutely all the time because he is the one that can say we used to do it this way what do you think, he has insight' (S5).*

In essence the design of the LSPA technology and the desire to introduce multi-disciplinary working within pathology may well have had an influence on supplier staffing structure, as well as user organisations. Whether that factor was a conscious decision on behalf of the supplier could not be ascertained. What was apparent however was that the sociomaterial affordances and constraints of the technology appeared to be creating a merging or entangling of the two organisations as scientists were expected to take a more hands off approach to laboratory work and user organisation staff take on the role of scientific advisor.

5.6 Influence of management consultants

During the construction of the template (Appendix 6) it became apparent that with regard to changing working practices and staffing structure, both the primary supplier HCS and implementation teams were both highly influential.

According to one user 'the HCS team and laboratory automation go hand-in-glove – you should not have one without the other' (Graham, 2011). Accordingly another high-level code was developed termed 'influences of homogeneity'. With regard to overcoming the difficulties introducing new technology within a healthcare environment, Prout (1996, p.211) identifies two potential solutions, the first is to 'redesign the device' and the second is to 'redesign the users', with the former considered to be more difficult than the latter. During the course of this research the focus of the primary supplier of LSPA technology turns to re-designing the user, no matter how difficult that may be.

All five managers stated that the involvement of primary supplier management consultants, and/or the HCS team would influence the introduction of the automated platform. The management consultants were perceived to bridge the gap between customer expectations of what could be achieved in practice.

> *'So I think we have taken a more holistic approach to automation implementation now. This has been quite a change from probably about no longer than a year ago, a strategy or idea of what healthcare solutions should be providing. The automation may have been positioned as being the cure all and hence there is a gap between the customer expectation and what can actually be achieved' (S3).*

> *'I think they* (HCS) *form a good bridge between the people that run the thing i.e. the customer and the people that install it and set it up'. I think let's be honest there is a massive gap between the marketers and the engineers and they do fill that gap nicely' (S5)*

> *'I think what we in healthcare solutions groups are doing should produce a better outcome than the way the technology implementation was structured a couple of years ago. If there were shortcomings in the current process then we would want to work with the laboratory to make sure that they understand what they have to do to make the process fit for purpose going forward with the new automation' (S3).*

'We make a distinction between transition management and change management. Change management is more about winning the hearts and minds of people, whereas we are using transition management to describe what we have to do from a process stand point to make the organisation and the process fit for purpose' (S3).

'because the customer doesn't fully understand the full utility they tend to stick to what they know and actually transfer the current processes and routing etc. to suit and so that is what they would give our implementers advice on what they actually want (S2).

Members of the implementation team also indicated that they were actually asked by customers to suggest changes to process. Knowledge transfer from one site to another through the implementation team therefore facilitates homogeneity of working practice as follows:

When you turn up on a new site and say what do you want and they suggest something to me as in "I don't know this equipment, I don't know what I want, if I try and tell you what I want I will probably miss the point, show me a good example, show me how I get there". With a number of sites now what I have created is a hybrid where I have said right you will like the haematology from there, you will like the chemistry from them and you will like this set of rules. Put it together and lay it in front of them, they massage it and often they only change a few percent'. 'I have a number of sites that are running on that premise where I have specified the way I run the lab because I have taken that approach of saying this works well for somebody else' (S4).

'It's clear as far as we can see what the customer would like is for us to come along and say here is what you can do with the product, this is what we can set up for you, rather than wait for the customer to come to us to say "well we think that we can do this what do you think"? The customer really wants us to say there you go, this is your system this is what we can do for you' (S5).

It could be construed from these comments that once purchased the users had either not fully considered the implications of the constraints afforded by the technology or were unable to address these issues without support from the supplier. In essence once they had purchased the system some user groups did not quite know what to do with the equipment. Within this context user requests for primary supplier intervention in changing working practice can be considered 'mimic processes' (DiMaggio and Powell, 1983, p.150). DiMaggio and Powell (1983, p.150) state that mimic processes occur as a result of organisational uncertainty, i.e. when 'organisational technologies are poorly understood, when goals are ambiguous or when the environment creates symbolic uncertainty'.

Three managers also stated that the introduction of the automated system would ideally require modification to working practice before automation takes place. Within this context, in line with technological determinism the technology itself is considered an independent variable and social practices used to support the technology the dependent variable.

> *'from the beginning one of the challenges that the company had was to really educate people at the time to make sure that you optimise and lean your laboratory before you put the technology in and do not expect the track to adapt to your current process' (S1).*

> *'we are trying to get more involved in the process prior to installation so that we can get a better look at the process rather than unpick a process that has been set up six months post installation' (S2).*

> *'what we recognise is that, you know there is a well-worn cliché that if you don't have a good process hat on, automating a bad process, you won't get the outcome you were intending. So yes, I would expect that now* (the primary supplier) *would certainly want to understand the current state and understand if the processes were fit for purpose for the implementation introduction of an automated system and if there were shortcomings in the current process, then we would want to work with the laboratory to make sure that they understand what they have to do to make the processes fit for purpose going forward for the new automation system (S3).*

Both members of the HCS team stated that the primary focus of any changes to working practice would be to the central reception or specimen delivery.

'The key requirement is to provide samples to the front end of the automation at the appropriate time in the appropriate quantities to get the optimum performance form the technology' 'Now if your process in the organisation is not geared to that pulse then you either overload the system at times during the day or it's running at under capacity' (S3)

'Yeah there is a time, and bear in mind that the implementation here had very little healthcare solutions involvement. You know we are coming in after the event and not exactly fire fighting, but we are finding out things and am sure will be making some suggestions if not recommendations as to how the process could be further optimised. But we certainly see that there are periods during the day like process, where the front end is definitely having an impact on the sample manager and they are out of balance. There are times though in the lab where the sample manager is sitting idle and actually we don't want that, we want the sample manager to be in constant operation, not over worked or under worked and by doing that the centrifuge which is downstream will be processing more optimally and samples will be distributed in an optimum fashion for the connected analysers' (S3).

With regard to unpredictable result turnaround times (nominally considered in a pathology laboratory to be the time taken from specimen receipt in a laboratory to the result being produced) one manager gave a practical example of how the HCS team overcame operational difficulties within a specimen reception area:

'We went in there and put out healthcare consultant group in to see what they were doing. There are all the lab cell trays like five of them sitting in accession (central reception). This accessioner was loading one in the first tray, one in the second and the third, rather than put everything they had in their hands in the trays they were spreading them out among multiple trays. You know a simple thing like that, how they were doing that I have no idea but that was the root cause of the unpredictable TAT because someone in accessioning was doing something rather dumb' (M1).

5.7 Review of template connections produced during the analysis of primary supplier interviews

A review of the entire template (Appendix 6) produced during the course of this research revealed a significant six way connection of issues highlighted by all five respondents as illustrated below in Table 16 below:

Table 16. Six-way connection produced during the analysis of primary supplier interviews

Number	High level codes	Primary supplier manager				
		S1	S2	S3	S4	S5
1	Technology expected to change working practice	**	*	**	**	**
2	Central loading point/single platform	*	***	***	****	****
3	Integrated middleware	****	**	****	*****	**
4	Expected to change staffing structure	***	***	***	**	*
5	Skill mix changes from qualified to junior/ non qualified	*	**	**	***	*
6	Supplier consultant fill gap between customer expectation and what can be achieved	**	***	**********	*	*********

All of the respondents expected the introduction of the automated tracking system to change the working practices within user laboratories, via the introduction of multi-disciplinary working. The primary design features, embedded within the technology to support the introduction of multi-disciplinary working, were considered to be a single automated platform with central loading point coupled to a system of integrated middleware. These design features were also expected to change the staffing structure within user organisations; with an overall reduction in staff numbers and a change of skill mix from qualified scientist to support staff. In addition all five managers also stated that primary supplier consultants played a significant role in bridging the gap between customer expectations and the use of the technology in practice. It will be argued during the course of this research that the influence of consultants in this environment also has a significant impact on the homogeneity of working practice across organisations.

5.8 Summary

The chapter has addressed two of the four primary research questions namely:

- **Do the developers of LSPA purposefully intend their technologies to shape the work practices of users or the structure of organisations?**
- **If so how do designers of LSPA technology embody their intentions in designs?**

Within this example the primary supplier designers of LSPA appeared to intend their designs to shape both the working practices of users and the structure of organisations in order to facilitate the introduction of multi-disciplinary working. The design of the integrated single tracking system, central loading point and integrated middleware was proposed to require minimal human intervention. As a result of the design of the technology it was also suggested that the technology could be operated by support grades of staff, rather than scientific staff. In an attempt to facilitate these changes it is also recommended that management consultants in the form of the primary supplier HCS team be utilised prior to the implementation phase to change laboratory working practice and bridge the gap between designers and users. The following chapters 6 & 7 will investigate the introduction of LSPA within two NHS laboratories in order to understand if these designs subsequently had the effects that the designers intended in practice.

Chapter 6 The implications of Introducing LSPA within Organisation X.

6.0 Introduction

Traditionally pathology laboratories have utilised stand-alone equipment to analyse patient specimens. Recent developments have included the introduction of LPSA systems, which aim to automate the vast majority of the manual process. This includes the use of an automated track for the delivery of specimens to individual analysers. The following chapter will highlight the acquisition, implementation and use of LSPA in a UK NHS pathology laboratory.

According to Leonardi and Barley (2008, p.164)

> *'to integrate materiality with a more voluntaristic stance requires that researchers attend directly to the specific ways in which the features of particular artefacts' become entangled in the social practices of peoples work. In addition to paying attention to studying the social dynamics such as perception and interpretation this means paying attention to studying what a technology lets users do, what it does not let them do and the workarounds that they develop to address the latter'.*

This work will then initially focus on the perception and interpretation of a group of pathology managers, involved or potentially involved in the acquisition of LSPA. Attention will then be paid to the selection, implementation and use of a single track LSPA system, provided by the primary supplier identified in Chapter 5 within Organisation X, where the researcher was employed as Haematology Services Manager between 2003-2010. The aim of this chapter is then to identify whether the primary supplier design intentions identified in chapter 5 subsequently have their effects in practice and if not why not?

Note: As the methodological stance taken during research was one of multi-site ethnography this work will reference the researcher as manager in the first person singular i.e. (I am).

6.1 Results of pathology manager interviews

In order to gain an insight into the perceived affordances and constraints of the automated pathology platforms a total of ten semi-structured interviews were undertaken with pathology managers throughout the N.E.Path modernisation area. This sample represented a manager from every single NHS Trust in the North East of England. At this point in time only one of these managers had actually purchased an automated tracking system. Therefore in addition to the above group two interviews were also undertaken with managers outside of the region who had also already purchased a dual track system.

Following full transcription of the interviews template analysis was carried out as detailed in Chapter 4 'Methodology'. During this work the researcher developed the high level codes of 'affordances' and 'constraints' *a priori* following the literature review. Subsequently other high level codes were produced in an inductive manner, following crystallisation and immersion within the text. A full transcript of the resultant pathology manager temples can be viewed in appendix 7.

Template analysis can then be utilised in one of two ways. Firstly it can provide us with a structured way of coding data, working from the initial *a priori* coding framework. Secondly, it can be used for content analysis, whereby frequency of mentions of a particular issue, gives us some guide as to the emphasis a respondent places on that issue. The relative frequency of these high level codes, are highlighted in Table 17.

Table 17. Summary of most frequent codes produced during N.E pathology manager interviews

Affordances	Number of respondents
Facilitate skill mix change	9
Promote centralisation	6
Build extra capacity	6
Accommodate workload out of hours (reduce stress)	5
Financial benefits	4
Perception or examples of modification	3
Reduce departmental barriers	3
Adapt to declining workforce	3
Constraints	
Requires changes to central reception	5
Increase result turnaround time in haematology	4
Physical size of equipment	4

6.1.1 Facilitating skill mix changes

The perception that the introduction of automated pathology systems would facilitate skill mix changes received the most number of mentions and was highlighted by nine of the ten respondents. Individual opinions as to how these skill mix changes would be realised, following the implementation of the instrumentation, was less clear.

One manager suggested that you should invest in technology for purely scientific reasons as follows:

> *'an analyser, like anything, you should really buy for effectiveness and not for the price. Whether you want to buy the most expensive or the cheapest I always think you should buy for scientific reasons so that is why I think there are different analysers on the market' (M2).*

For this manager the perceived affordance offered by the system was limited:

> *'we are going to save two medical laboratory aid's that's the only benefit the track is going to give us, because the way we review will be exactly the same, we still need people to review QC (Quality Control), people to do training. It's going to save us two medical laboratory aids, is that a benefit? If you can recruit medical laboratory aids, what are you saving because the medical laboratory aid can do lots of useful things so are we saving? Not sure (M2).*

During the interview I felt that this comment was ironic in that the cost of an automated system could run into the tens of millions over the lifespan of the project. Yet the only advantage this manager could foresee was the loss of two medical laboratory aid (support staff), which by his own admission are the most flexible group working in pathology.

Another manager who already had experience of an LSPA system indicated that the skill mix changes would also be facilitated by reducing the number of support staff as identified below:

> *'We have not seen it yet, we do hope to reduce support staff. Again if you go back to the benefits of the whole project if we have full electronic requesting and if we have online centrifugation working good, and we have the re-cappers working good, then we can see that the front end staffing will decrease' (M1).*

Following this response I asked a subsidiary question: Do you think that it will change the level or grading of biomedical scientists as well?

> *'we always get back to staffing levels and the number that you need to run a rota; you need a minimum amount of scientists to run the out of hours during the night' (M1).*

Conversely other managers stated the opposite in so much that increasing the number of support staff support would bring about skill mix changes. Increasing the number of support staff was viewed as a means of allowing this group of staff the opportunity to undertake some of the duties currently performed by biomedical scientists, who would in turn be free to undertake more complex tasks.

> *'there will be skill mix change with biomedical scientists and they will have more time to do other things than the track', 'not reducing staff but changing the skill mix', 'we will remould the workforce so that senior staff are doing quality aspects of the work which now they constantly say they don't have time to do' (M3).*

> *'not deskilling but opening the track to other members of staff, to our support staff to allow our biomedical scientist staff to concentrate on their skills' 'it's all part of the bigger picture to future proof the department' (M4).*

> *'definitely as a means of changing the staffing structure to skill mix to using more healthcare assistants or workers to work the track and skill mix up for those scientists who have the capability to have more, to work more as a consultant, that's what I thought that the track could do' (M8).*

In contrast one of the managers who actually had practical experience of an LSPA system stated that the ability to modify the skill mix was driven by the perceived simplicity of the automation:

> *'Their job descriptions are different, the level of skill is hugely different but as far as the track is concerned there is very little intervention needed to run it. You don't need to be an IT consultant to run one of the (primary supplier) tracks. If you can stop and start the analyser, stop and start the robots, rack errors that sort of thing' (M5).*

> *'We are going to get the medical laboratory aids to check reagents, load cuvettes, check the water doing the wash, weekly maintenance. So instead of just being a group of staff who prep samples* (specimen reception and data entry) *they are now a group of staff who feel that they have ownership of the whole automated system' (M4)*

For some managers the introduction of automated tracking systems was viewed as a means of compensating for increasing workloads and the inability to recruit new staff, rather than a means of reducing the overall staff numbers.

'this is our workload and this is how it's increasing, we are not getting any more staff and there are more and more pressures being put on our biomedical scientists, to do with CPA (Clinical Pathology Accreditation), blood film reports etc. How can we manage our workload more effectively and release those staff and that's why I thought that the fully tracked automated route would be the answer' (M4)

'I have had two biomedical scientists retire and one who's thinking about retiring in the next three years so of course you are losing all of that expertise. We can't get the staff in quickly enough and up to speed. With that in mind not deskilling but opening up the track to other members of staff, to our support staff to allow our biomedical scientist staff to concentrate on their skills to allow for training to bring our younger members of staff up to speed is all part of the bigger picture to future proof the department' (M4).

'getting back to tracking systems, there is the year on year increase in workload, if you look at statistics and productivity it is unlikely that we will get more staff, hopefully automation will be the answer. Not reducing the staff level but changing the skill mix' (M3).

6.1.2 Laboratory centralisation

The issue of laboratory centralisation ranked as the second most popular response within the 'affordance' template (Appendix 7). The issue of laboratory centralisation could have ranked higher in the template if two of the managers interviewed had not been employed by organisations outside the N.E. region.

During the production of the template it became apparent that the term 'centralisation' was being used by some managers to describe the consolidation of services within their own organisation. During this period I attended a conference where a keynote speaker was Dr Rachel Leibman Registrar of the Royal College of Pathologists. During her presentation Dr Leibman stated that that the adoption of LSPA was simply a "defence mechanism" (Leibman, 2010) against the oncoming modernisation agenda. As described in the literature review the UK Government's drive to modernise pathology services was built around the formation of a formally managed pathology network. This network was perceived as being built on what was locally termed a ‘hub and spoke’ model. Within this model the centralisation of the majority of non-urgent ‘cold’ work from small laboratories would be consolidated into a large ‘hub’ laboratory. As a result the small ‘spoke’ would be left with only acute ‘hot’ work from the inpatient population. In essence if organisations purchased huge pieces of equipment especially under the umbrella of a long term MSP, they would defend themselves against wide-scale rationalisation as part of the modernisation agenda. It is argued as part of this research that the views of the managers involved within N.E.Path represent a ‘defence mechanism’ against pathology modernisation. By entering into long term contracts and filling laboratories with LSPA Trusts involved within N.E.Path were preparing to create a centralised ‘hub’ laboratory within their own organisation as highlighted below:

> *‘I suggested about three or four years ago to* (Organisation G) *why don’t we have the same equipment the same normal ranges, But I think that they see* (Organisation B) *as a predator. Sitting in* (Organisation B) *you don’t think that, you say how do you provide a better service and at that time* (Organisation G) *had the same cell counters as us the same transfusion the same coagulation. I suggested a good idea but they went down a different route, they must have had their reasons. Someone could sit anywhere and look at the QC on-line. I just thought that it had so many pluses it would have been great for the* (Organisation G) *to say this is the normal range for* (Organisation G)*. We may still get there!’ (M2)*

Four of the eight Trusts within the North East of England were identified as wanting to consolidate services within their own organisation and it is argued here to shape their organisation as a pathology hub as illustrated below:

'Just to clarify that we have tracking in two sites but not the third. There were a lot of drivers, first of all there was the time when we merged the Trusts, previously (Organisation 1a) *were one Trust,* (Organisation 1b) *was another, and pathology was the first to merge themselves into a single managed directorate that's where started from. Obviously being separated before we had all separate equipment, which was all due to be replaced at different times. So we wanted to standardise equipment within each discipline, so that was the driver to standardise equipment' (M1).*

'What's interesting is that the fact that when first things were first planned, should we have one big laboratory in (Organisation B)*, what is the advantage of having one big laboratory in* (Organisation B)*? We then looked at three options, one big laboratory in* (Organisation Ba) *and a hot lab at the* (Organisation Bb)*, so we looked at those three options' (M2).*

'as you have probably heard in the press there are plans to build a new hospital at (Organisation G), an emergency care centre with a prime position from (Organisation B) but there is a guarded yes to the plan and it looks like it will go ahead. We have built to change both instrument, potentially have a track our intention is to centralise blood sciences in the new hospital' (M7).

'we are trying to get away with centralising GP work as well which accounts for 50% of the work. So if we have got that size of lab up there, which is going to cope with the current workload of three current blood science labs it is going to be a very different looking lab, it's going to be quite big and I think at that point it makes sense to consider a track' (M7).

'We don't plan to change yet but obviously if we do get funding for a new hospital we will become blood sciences and look at a tracking system then but speaking to people around the region we would probably look at tracking for Biochemistry and Immunology and keep Haematology out of it. (M9).

The pace of potential change identified by this manager is highlighted below:

'we are hoping to find out within two to three months and if we stay on this site we are volunteering to move out of the main hospital building. If they want to custom build a lab for us across the car park and free up this space for an acute service which the Trust are looking favourably on we get a new build and they get more room' (M9).

During this period of the research I was unaware that tentative plans were already being considered to centralise pathology services between three neighbouring organisations in the North East.

Template analysis (Appendix 7) revealed that for two of these three site managers any mention of rationalisation was starkly absent from the results (M3 and M6). The issue of centralisation of services was however the primary theme of manager 10, who was the manager of the smallest and hence most vulnerable of the three. The following passage of reference provides first hand evidence that the pathology modernisation agenda is in this case delaying technological change.

> *'We had a clear vision but that was four of five years ago, Carter (Lord Carter review 2006, 2008) has destabilised our vision. The networking and our local bigger picture collaboration has us all in the melting pot and it could be for example that one of our laboratories ends up as a hot lab, what happens to the tracking system then? So I don't think that there is anything wrong with the concept but it is all geared up to volume going through here I can't see us going heavily down the automation but at the same time you can't discount it' (M10).*

6.1.3 Build extra capacity

Template analysis (Appendix 7) identified that for six of the managers one of the key affordances of LSPA was to increase capacity within their organisation, which in itself became the third most popular affordance code. This extra capacity would be used to accommodate perceived future reductions in scientific staff numbers. Adapting to a declining workforce was then also included as a high level code.

> *'Getting back to tracking systems there is the year on year increase in workload, if you look at statistics and productivity it is unlikely that we will get more staff, hopefully automation will be the answer' (M3).*

'but that was it, to future proof the department, like every department I have had two biomedical scientists retire and one who's thinking about retiring in the next three years so of course you are losing all of that expertise. We can't get the staff in quickly enough and up to speed' (M4).

Only one manager openly stated that the requirement to build extra capacity was linked to a potential to receive work from other areas.

'if you then look at the competition, in this new era that the government has been talking about, trying to get additional work in, what is the only work you can get in? I think that it is GP's. The GP's will still want the turnaround time to be by the next morning, even though the patient does not come back for a week'. (M2)

Once again it can be seen, that in the opinion of this manager, the pace of technological change would appear to be driven by the uncertainty of competition within the UK government's modernisation agenda.

6.1.4 Accommodate increased workload out of hours

An unexpected finding revealed by template analysis (Appendix 7) concerned worker stress levels during the 'back-shift' period, which is organisationally variable but would on average cover the 17:00-21:00 period from Monday to Friday. During the backshift a great deal of work comes into most pathology laboratories from primary care GP's via transport runs (personal observation). The traditional staffing patterns of biomedical scientists revolve around increased payments during the 'out of hours' period and hence pay little attention to the demands of the service.

In this example, the ability to manage large workloads is also associated with a high degree of stress, which will be demonstrated later in this research to be accepted and maintained by staff in return for the associated large financial compensation.

In response to questioning on the effect of automation from a work-life balance perspective one manager stated the following:

> *'back shift in particular was extremely stressful, we get half our workload, close to 1000 samples between 4 and 9 o'clock and of course you reduce staff there and staff were getting extremely stressed. The work ethic of people here is that they work until it's done, back shift can relax now the stress has gone' (M4).*

Manager 6 also raised the issue of stress reduction:

> *'yeah work life balance is something that we have been trying to address for a long time the impact of the shift in particular. The technology especially the pre analytical side has improved work-life balance; it's the team that work the late shift in particular because pretty much all the work is done by eight o'clock and then it's just emergency work. The facilities that are available to them make them feel less stressed' (M6).*

A connection was made in the 'affordances' template (Appendix 7) whereby five managers all stated that skill mix changes would be associated with changes to practice during the out of hours period. Hence it can be argued that managers were prepared to purchase wide scale automation over a ten year period because they felt unable to smooth the workflow during the day and unable to address the traditional working patterns of biomedical scientists during the out of hours period. If more staff were needed, support staff could be employed of which there are no national shortages. The skill mix change could be brought about by the simplicity of the new technology as highlighted above and hence the stress factor could be managed indirectly.

6.1.5 Financial benefits

The fifth most common response regarding the affordances of the technology revolved around the financial benefits of either reduced staffing highlighted above or via the MSP agreement with a primary supplier as highlighted below.

> ‘we also had two computer systems so we had two big projects. The benefits that we are getting are joint benefits from those two systems. From the equipment we have a managed service contract, which covers all disciplines, within the MSP there are financial benefits’ (M1).

For one site that had purchased a dual track system it was acknowledged that the introduction of a system for Haematology was part funded by a comparative system within Biochemistry.

> ‘we were lucky in that we entered into the managed service contract with biochemistry, if we did not go with biochemistry we would not have that track, because we did need some of biochemistry’s money to fund that’ (M4).

For other managers however the cost of the system proved to be a constraint either through lack of funding or supplier disinterest:

> *‘As it happens none of the manufacturers came back with full tracking for us we were just below the threshold to make it effective (M9)’.*

6.1.6 Perception or examples that the system could be modified in use

During the construction of the template (Appendix 7) an unexpected code began to develop around the managerial perception that the automated system could or would be modified after purchase, to adapt to the working practices of the laboratory. Manager 4 who already had a tracking system installed illustrates these perceptions as follows:

'the implementers came in and we said right this is what we want it to do', "but it can't do that mate sorry", 'but it was sold to us because we want it to do this and that and they went away. One of the implementers said to a guy on the backshift, do you think they want it to make the tea as well' 'then the penny seemed to drop it's a haematology track only', but we can do it and the proof of the pudding is we will come here and do it now' (M4).

This manager went on to give some examples of post implementation modification based on how the laboratory decided to process urgent specimens. As highlighted in the previous chapter one of the perceived design constraints of LSPA revolves around a physical limitation on the number of pucks a track can accommodate. In order to accommodate these constraints the system designers had developed 'a whole new layer of software' to essentially allow the system to identify and prioritise specimens highlighted electronically as being urgent.

In practice however this laboratory had developed a workaround whereby urgent STAT specimens were manually front-loaded onto the analysers in the same way specimens had been presented within the traditional mode of operating standalone analysers, in essence bypassing the technology completely as highlighted below:

'they (support staff) *have responsibility for opening up the sample and for putting it through the analyser either as a STAT or put it through the analyser themselves, that way it is prioritised. We aim to turn A/E and clinics around in an hour and there was a time when we were going over that, so we have gone down the route and tightened up our practice' (M4).*

Even managers who had not purchased the system could see the potential to modify the system after implementation:

'We asked if we could make some alterations, they would not let us make alterations, at the moment, but I am sure that when we get it in we will try and work with them'. We have looked at the system that we think will suit the laboratory best with how the work flows in our laboratory so that is what we are trying to do (M2).

The third manager who discussed modification made a more practical suggestion in that

'It's all on one line it can all be dealt with by a single group of people you don't have centrifuges off line you can have them on line it. If you want to expand it you can just bolt another box on the side of one line' (M3).

For some managers there was a realisation that the purchase of a LSPA system was not static but fluid, in that increased capacity could be achieved by adding additional instrumentation directly on to the track. Indeed the track itself could be lengthened or shortened in required.

6.1.7 Reduce departmental barriers

Finally a number of managers felt that the introduction of the tracking system would reduce departmental barriers. However in the first example the department still operated with a dual track system and therefore did not utilise the design features of a single-track system identified by the primary supplier at the centre of this research in the previous chapter.

'it's probably a pareto thing if 80% of the assays tended to be chemistry assays then the chemistry lot would look after that machine and run 100% of the assays that went on it. If 80% of the assays were haematology they would look after it. Now when any new technique comes in it's who does that to be most process efficient not this is a chemistry test etc. Selling that to the staff moving forward that's the way we are trying to deliver solutions because if you reduce to think about the patient, this was all patient centred, think about it from the point of view of the patient'.

Only two managers were purchasing or considering a single-track option designed to introduce multi-disciplinary working i.e. the bringing together of both technology and staff within a single-track system. In this respect this finding corroborates the primary supplier findings that only 15-20% of laboratories worldwide have opted for the single-track version.

> *'We went for one tracking system to amalgamate the departments. The other option would have been to go for two separate systems, do you think that was a good decision. Other places Organisation Y for example have gone for two separate tracks. It's a bit long ago but I think now we have one entry one tube management system at the front end if you have two then you have two different systems so that is probably one of the things (M8).*

For a manager who had yet to purchase the system but whose preference would be a dual track the reasoning behind the decision to purchase a single track rather than a dual track was quite simple

> *'The only reason that I can think of is that they don't want a blood science* (combined biochemistry and haematology) *department if you go for two you are creating an automatic divide' (M7).*

6.2 Constraints

During the creation of the pathology manager's template (Appendix 7) perceived material constraints of LSPA technology were also highlighted and these are described in more detail below.

6.2.1 Changes to central reception area

The primary material constraint identified was that the introduction of an automated system would require social and material changes within the specimen reception and data entry areas.

> *'Our plan is to have a combined reception area; from that combined reception area you would have a track coming off. So rather than having a combined reception area in one big track, to have a combined area in a one track which will do chemistry work and the haematinic work and another track coming off which will do FBC' (M2).*

For laboratories that had previously operated with two separate reception areas one for biochemistry and one for haematology the introduction of the automated system was seen to require a ‘combined reception area’ (M2). Rather than have a single access point to one system this was seen as a means of allowing the laboratory to operate in a ‘hub and spoke’ (M2) arrangement whereby a number of tracks would extend from a single point.

Other managers were influenced by the supplier organisations implementation and support teams, who adopted lean principles within the laboratory and recognised that it was probably more efficient to have the single access point as close to the reception area as possible, to minimise staff motion through the laboratory.

Manager 8 highlighted an issue, which will be explored in more detail in later sections of the research in that the adoption of an automated tracking system often requires the reception staff to accurately manually apply barcodes to the specimen bottles. Problems arise if the barcode is not physically attached in the right position or angle. It must be noted that this manager had many years’ experience of ‘lean’ practices and the trust as a whole had undergone an organisational review as part of the North East Transformation System (NETS) (Durham University School of Medicine and Health and Newcastle University Business School, 2008).

As such this manager talked in terms of ‘the theory of constraints’ and ‘defect management’ (M8).

> *‘we classify an error as where there is manual intervention, that is where we get the most errors’. ‘The whole gamut of that human interface usually causes the problem and what solutions could be used to minimise or exclude those opportunities’ (M8).*

> *'I find that when you do your lean process work if you constrain the process so that it can only be done that way then the process will always be done that way' (M8).*

With regard to the pre-analytic phase:

> *'One of the issues that we always used to have was the medical laboratory assistant labelling up the tubes because they would always either put the label on incorrectly or they would put the wrong label on the wrong tube'. What happens now is that because the medical laboratory assistants man the track system they self-correct themselves because they are responsible for labelling the tubes. If the system spits them out and say's I don't like that the medical laboratory assistant then has to take them back and correct the fault, we don't get any faults now. In three weeks it was gone' (M8).*

> *'It's them, they are their own constraint, there are consequences to their actions and that are a constraint in the process that makes them understand it is important to do their part of the job'* (M8).

The embedded design feature that of a single integrated tracking system would constrain the process due to the volume of specimens and the limited number of transport pucks as highlighted below.

> *'so our track runs quite empty in general, 15-20% of the pucks are full, but in biochemistry the same set up with different analysers doing different profiles one sample may have to go to three different analysers in queues so the pucks start to get full and you have a finite amount of pucks. If for any reason there is any problem with the biochemistry side the haematology can't get on. I think that is the negative thing about a combined track (M5).*

> *'the majority of haematology samples are full blood counts and I can't see the point of delaying them through the biochemistry track when you can stick them straight on an analyser' (M9).*

For a number of managers the design features introduced as part of a single integrated tracking system and central point of loading required a delay to be built into the process.

The materiality of the system resulted in a change of working practice because staff were no longer able to undertake a common workaround (discussed later in this chapter), whereby haematology specimens were placed on the analysers before data entry had occurred as follows:

> *'we had to modify the process in that before we had stand-alone analysers, you took the samples and you would throw them on and book them in later (patient demographic data input) and they would just marry up. Of course you can't do that on the track they have to be booked in first, so we have had to build in a delay in that they sit in the racks. An medical laboratory assistant or biomedical scientist will then check on the track interface before they are loaded, so it's a bit of a pain but we had to build in a delay' (M4)*

In essence the materiality of the technology embedded by the designers i.e. a central loading point created a constraint within the specimen reception and data entry area that required modification to working practice with this laboratory as with Organisation X.

6.2.2 Physical constraints

During the course of the interviews a number of individual managers noted a number of physical constraints of implementing the new technology primarily due to the combination of physical size of the equipment and access to laboratory areas. The selection of a single rather than dual system was therefore constrained by geography:

> *'We were impressed by* (manufacturer x) *but to get everything that we needed we would need a scaffold outside those lockers out there. So the decision was kind of made for us in a way' (M4).*

During the course of the template analysis a number of additional observations were made leading to the production of a number of additional high level codes, including the influence of site visits, relationship development with the primary supplier and the influence of management consultants.

6.3 Perceptions developed from site visits

Although not asked directly about the influence of site visits during the initial line of questioning, a number of respondents noted that the perception of affordances and constraints were developed as a result of site visits to other organisations. In total seven individual sites were mentioned by name and appear as organisations (t-z) in the final template (Appendix 7). These visits were seen to significantly influence the decision to either purchase a system at all, or select a single track over a dual track system.

> *'they said they were thinking of putting a track in on the site where they did the GP work but the chemist's put their hands up in horror , and I can't remember the guy's name but he smiled and said I thought that would get the chemists. But when you have a track you have to make decisions and some of them are not the obvious things. There is a school of thought that if you are building a new place that you must have one, but he is the person that made us think' (M7).*

The perception of one manager was that the dual system he viewed in Organisation (u) was of no benefit as follows:

> *'We thought that the* (single track system) *we saw at* (Organisation u)*, was of no benefit, it was not actually enhancing the laboratory' (M5).*

For some managers the site visit was a positive experience:

> 'When we went to (Organisation t) *and saw their track and ok it's all singing and dancing, it gave us a vision to say right we can see it in reality. We had never thought of tracking coagulation before and it got us thinking about coagulation as well' (M4).*

However the site visit had a negative influence on this management team because they opted for a dual track system based on a perception of increased result turnaround time:

'because early on when you were doing site visits and when you heard from people on site visits there could be a detrimental effect, especially in haematology on a combined track'. So our (dual) *track runs quite empty in general, 15-20% of the pucks are full. In biochemistry, the same set up with different analysers doing different profiles, one sample may have to go to three different analysers in queues, so the pucks start to get full and you have a finite amount of pucks. If for any reason there is any problem with the biochemistry side the haematology can't get on. I think that is the negative thing about a combined track (M5).*

6.4 Relationship development with supplier

For two managers who had already purchased the new automated systems as part of a MSP, the perceived benefits of the track system were more than material. The potential to develop long-term relationships with the supplier became a significant feature of the venture:

'That's why we ended up with Organisation X "good relationships". They listened to what we had and came back extremely slick and had answered all the questions' (M4)

'what we wanted to have was a partnership with a company that would understand our requirements and then move us forward', 'what we were looking for was the whole company design philosophy' (M8).

6.5 Influence of 'lean' manufacturing principles

In order to facilitate changes in the laboratory, nine out of the ten managers suggested that they would utilise 'lean' principles to facilitate the introduction of the technology. The most extreme example was obviously the organisational influence of the NETS programme on Manager 8.

6.6 Implementation and operation of LSPA in practice within Organisation X

The following section of this chapter will assess the impact of LSPA within Organisation X

6.6.1 Overview of Organisation X

Situated in the North East of England Organisation X is a large NHS Trust comprised of two individual hospitals. The combined workforce of both hospitals is almost 9,000 and together they provide a range of services to 1.5 million people.

In the North of the region is a 1000- bed major tertiary referral unit providing a comprehensive range of regional specialities including cardiothoracic, neurology and vascular surgery. The A&E department is the designated major trauma-centre for the southern half of the northern region and the hospital has a dedicated 24-hour acute admissions unit.

In the south of the region there is a relatively small 225-bed district general hospital providing local medical services including A&E and maternity to a population of 120,000 people, covering an area of 1000 sq. miles.

Although both of the above hospitals described above benefited from the introduction of automation provided by the primary supplier at the centre of this research only the large hospital situated in the north of the region adopted LSPA technology. The remainder of this chapter will then focus on the adoption of pathology automation within this hospital, which will subsequently be referred to as Organisation X.

6.6.2 Technological change within Organisation X

As Haematology Services Manager within Organisation X, senior colleagues within biochemistry and I were faced with a technical dilemma during 2006. The existing standalone equipment currently being utilised within the department was reaching end of life and required replacement.

6.6.3 Site visits to centres of excellence

Following a conversation with the primary supplier identified in Chapter 5 a number of senior managers, including the clinical director of pathology and I, were invited on a site visit to a laboratory in Spain. This site visit was primarily arranged in order that the primary supplier could showcase their newly developed LSPA technology. Personally I felt that this visit was a fantastic opportunity to investigate a top performing international pathology laboratory. As expected the site visit was professionally organised with no expense spared.

The laboratory site in Spain showed extensive technological investment, in a state of the art laboratory setting. This site had opted for the primary supplier single-track option as described in Chapter 6 and illustrated in Figure 7, the laboratory was entirely multi-disciplinary, in that both haematology and biochemistry analysers were linked to the single track. The department fully utilised the primary supplier integrated middleware, which in this case was linked to a Hospital Information System (HIS). As a result the entire pathology process for haematology and biochemistry was paperless.

The staffing structure within the laboratory in Spain also differed between that of a comparative UK laboratory, with regard to the use of support staff. Highly trained and skilled support staff and not biomedical scientists performed routine processing on the tracking system. Within the Spanish laboratory use of support staff to perform scientific duties was considered the ‘norm’ as the equivalent role in the UK of ‘qualified biomedical scientist’ appeared not to exist.

In the Spanish laboratory clinical validation of abnormal results occurred in a room adjacent to the laboratory and hence was separated from routine processing. In essence, the validation step could have been performed remotely from anywhere if appropriate Internet access was available. As I reflected on these changes, it became apparent that the pathology process with which I was familiar was no longer the only option. If the scientific element of the process could be disentangled from the technical aspects of running the technology, a new dawn of 'virtual' biomedical science could potentially be realised (personal notes). Although, at the time, I realised that this site visit was arranged to showcase a premium site, on reflection this laboratory was utilised to demonstrate the ideal primary supplier solution as described in chapter 6.

Interestingly on the journey home from this visit, very little was said between the members of staff from Organisation X and certainly no decision was made to select that particular supplier there and then. However on reflection I think that all of the managers present thought that they had witnessed the future of pathology services. Although I undertook a number of other site visits to premier laboratories within the UK, no other site matched the 'wow factor' of the Spanish visit (personal notes).

6.6.4 Development of a MSP

During these initial conversations with the primary supplier I also became aware of a new mechanism for LSPA equipment purchase, whereby a single tender could be issued with a single primary supplier, brought together via a single MSP. The opportunity to purchase technology via a MSP offered significant affordances. The primary supplier would provide the majority of equipment, reagents and consumables required to undertake a given workload as defined by the user. The option of a MSP however also constrains the user in so much that the organisation is contractually committed to the single supplier for the entire length which normally between 7-10 years. In order to introduce an element of flexibility, a refresh element would be built into the contract, whereby after a given timeframe, all of the equipment could be replaced in order to take advantage of any technological developments. In return the primary supplier would be guaranteed to maintain the business for an extended period of time. In essence the supplier would take on a degree of 'organisational risk' in that the capital element of the contract, the technology itself, remained the property of the supplier. In return the supplier would reap significant revenue returns in the form of the reagents and consumables required to operate the system over the life span of the contract. The attraction to the user of an MSP was mainly the avoidance of protracted single tender applications, the assurance that equipment would remain up to date and more significantly the ability to reclaim Value Added Tax (VAT). The MSP option was then sold as more than just a contract between supplier and user for equipment and reagents. The transfer of organisational risk involved the provision of an entire support service including site evaluation, process review, training, on-site engineering support and improved stock management. In essence the MSP represented a significant long-term relationship between supplier and user. The successes of the relationship between the supplier and user would then be built on the mutual success of both organisations. From a more cynical perspective it could be argued that the MSP represented little more than the outsourcing of pathology services to the private sector.

6.6.5 Business case development for LSPA within Organisation X

During 2006 my equivalent colleague within biochemistry and I began work on the production of a joint business case for the replacement of the majority of the technology utilised within the departments of biochemistry and haematology.

The business case produced during October 2006 highlighted the aims of the project as follows:

> *'the current generation of laboratory automation systems can link together instrumentation from different pathology disciplines that have traditionally functioned as completely independent entities. The new system would therefore break down these traditional barriers, and facilitate cross discipline working, with re-defined roles for both qualified and unqualified staff' (Organisation X, 2006).*

The key objectives were listed as follows:

- Provision of laboratory equipment for both sites of high analytical quality that has the capacity to meet the levels of demand predicted.
- To streamline processes in line with the principles of lean manufacturing
- To reduce staff costs
- To promote cross discipline working and expanded roles in line with the principles of Pathology Modernisation
- To standardise and improve turnaround times for routine analyses to improve patient service and facilitate achievement of waiting time targets.
- To reduce non-pay costs
- To provide flexibility to cope with significant changes in workload (Organisation X, 2006)

The business case (Organisation X, 2006) highlighted that the introduction of the LSPA technology was expected to influence the staffing structure as follows:

'Introduction of laboratory track systems leads to two main workforce issues; skill mix changes with overall reduction in staff numbers, and changing roles with the potential to work across traditional boundaries'.

'It is envisaged that the reduction in staff will be brought about during natural turnover (currently 6-8%), with deliberate re-profiling of the workforce to increase the proportion of unqualified staff working within the laboratory. From approval of the business case onwards the employment of temporary contracts will be pursued when appropriate'.

'It is likely that more savings can be realised following bedding in of the system. However this release of staff could be used to reduce referred tests, service developments and the development of new technology' (Organisation X, 2006).

The business case also highlighted the potential strategic impact of increasing capacity in line with pathology modernisation:

'once in place, the extension in workload is easily accommodated therefore expansion of services for additional work from neighbouring SHA's etc. is possible with minimum increase on resource expense (income generation). The commercial opportunity is dependent on the development of PBR (Payment by Results)*, the national tariff, transport issues and the competitive environment' (Organisation X, 2006).*

Following management approval of the business case (Organisation X, 2006) my colleague from biochemistry and I were requested to produce a tender specification document (Organisation X, 2007a) for distribution to all interested parties.

An overview of the required service provision is highlighted below:

'To introduce an automated system for analysis of blood and body fluids, encompassing all pre-analytical, analytical and post-analytical sample handling, along with data management. The system will include instrumentation for general clinical chemistry, immunoassay, haematology and coagulation, along with appropriate instrumentation for pre and post-analytical sample handling. It will also incorporate provision of consumables for other existing equipment, and option for provision of further instrumentation requirements as they arise. The Trust is seeking a prime contractor for a managed service to supply

comprehensive, clearly identified and defined laboratory solutions. The selected supplier will be required to enter in to a contractual agreement with the Trust that clearly identifies areas of process responsibility and risk management, process control, performance and contract management and monitoring, along with defined standards. Tenders are to be invited from commercial companies to provide a solution that meets the requirements listed below, which will include a pricing for a minimum 5 year period, with options for 7 and 10 years' (Organisation X, 2007a).

Although the tender specification did not explicitly specify that the technology should comprise a single-track it was certainly strongly indicated in that the successful bid would have to include instrumentation for biochemistry, haematology and blood coagulation a subsection of haematology.

Two documents (Organisation X, 2007b; 2007c) produced by my colleague in biochemistry for the senior management group identified the critical success factors for the project and were much more explicit in highlighting the single track option as the preferred option as highlighted in table 18 below:

Table 18. Critical success factors following the implementation of LSPA technology in Organisation X adapted from Organisation X (2007)

Factor	Measure	Timescale
Staff savings of 34K per annum (minimum)	Change of skill mix and reduction of biomedical scientists.	2008 – 3 months following implementation
Achieve Financial savings	Budgets	End each financial year, monitor quarterly
Reduction in turnaround times	Turnaround time of maximum 1 hour achieved for 95% of inpatients	October 2008
Reduction in non-analytical error rate	Pre-analytical error rate reduced to <0.5%	October 2008
Reduced expenditure on referred tests	Expenditure reduced per annum as per financial schedule.	End each financial year, monitor quarterly
Streamlined processes	Fewer steps from sample receipt to production of results	October 2008
Cross disciplinary deployment of staff	Analysers for biochemistry, haematology and virology all linked to a track. Support grades performing basic tasks for all disciplines.	October 2008
Streamlined supplies management	Lower levels of inventory stock of consumables	October 2008, monitor quarterly

The influence of the Spanish site visit is all too evident within this review of the critical success factors highlighted above. The 'cross-disciplinary deployment of staff' (Organisation X, 2007b, 2007c) requires the technology from previously disparate departments (biochemistry, haematology and virology) to 'all be linked to a track' allowing 'support grades of staff to perform basic tasks for all disciplines' (Organisation X, 2007b, 2007c). Reference here is made to a single track being able to link all pieces of technology. From this perspective the only manufacturer of a single- track system capable of fulfilling the business case requirements would be the primary supplier identified in Chapter 6 as all other suppliers offered only the dual track option. Accordingly, the LSPA technology would allow a 'change of skill mix and a reduction in the numbers of biomedical scientist staff' (Organisation X, 2007b; 2007c). As such the business case and supporting documentation produced by Organisation X for the introduction of the LSPA system appears to match the design intentions of the primary supplier i.e. to introduce 'multi-disciplinary working'.

Following the tendering process the managed service contract was awarded to the primary supplier identified in chapter 6 during 2008. The selection of the single-track option mirrored the technology that the management group had viewed during the visit to Spain.

The site visit to Spain would then appear to be a significant factor in homogeneity of working practice across both of these sites, bridging the gap between design and use.

6.7 Material affordances and constraints pre implementation

Having already viewed the technology in practice within the laboratory in Spain, I was acutely aware that introduction of LSPA would offer a significant number of perceived affordances and constraints. Table 19 highlights the key affordances as identified within the original business case (Organisation X, 2006).

Following personal observation and in-depth discussion with senior biomedical scientists within Organisation X (personal notes) I have also devised the associated list of constraints as highlighted in table 19 below:

Table 19. The key material affordances and constraints perceived by management within Organisation X pre implementation of LSPA adapted from Organisation X (2006).

Perceived affordances of automated Pathology technology	Perceived constraints of automated pathology technology
Single integrated process encompasses most of the pre-analytical, analytical and post analytical stages within the laboratory	A single specimen entry point requires a single integrated process for specimen reception rather than multiple access points to individual standalone analysers. A single point of entry for all specimens requires all patient demographic information and test requirements to be entered onto the LSPA system prior to analysis.
Sample flow is smoothed since samples are analysed singularly or in very small batches, reducing or eliminating queues, assisting in optimisation of patient flow.	Sample flow will not be smoothed by the technology without significant modification to specimen reception and constant delivery onto the system
Turnaround times TAT are improved facilitating achievement of waiting time targets.	Throughput could be constrained by the availability of on- line specimen handlers, centrifuges and pucks. Reduced flexibility of manual loading of instrumentation could increase result turnaround time
Urgent samples are easier to prioritise and track	Lack of human involvement may result in a lack of prioritisation and less attention given to urgent samples
Sample locations and stages of analysis can be monitored at all times	Increased reliance on multiple barcode readers to assess specimen position
Flexibility as track can be lengthened or shortened to accommodate varying numbers of analysers as demand changes	Decreased flexibility inability able to physically move analysers. Proposed single track option are inherently static, 25 meters long and relatively fixed form
Reduced error rate due to fewer hand over stages (human contact) and fail safe checks built in to instrumentation	Any failure of the track system will result in the entire process coming to a standstill affecting all departments
Reconfiguration of process via the introduction of a multi-disciplinary automated floor	Materiality of the system brings staff together by virtue of technical platform rather than traditional departmental boundaries
Facilitate skill mix changes	The introduction of automation will be viewed as a perceived threat to staff and will be met by resistance (no redundancy policy)

6.7.1 The influence of 'lean' management consultants within urban site Organisation X pre-implementation

During this period of the research and quite by coincidence, a 'lean' management consultancy LMR® approached the CEO of Organisation X and offered their services free of charge in order to gain experience within the UK NHS. I was then subsequently approached by the Trust CEO and I accepted an invitation to work with LMR® for an initial two-week period in order to gain first-hand experience of 'lean' methodology. The LMR® consultants were exclusively comprised of past employees of Toyota UK and I felt that this was a great opportunity to gain first-hand experience of the TPS. During a preliminary meeting with representatives from LMR® I suggested that we focus on the haematology process from the sample being taken on a ward, to the final delivery of the result.

The lean assessment within Organisation X began with the identification of an appropriate end user group. I suggested to LMR® staff that we contact staff members within A&E and Cardiology Ward, 29, as staff within both of these areas had previously expressed concerns over haematology specimen full blood count result turnaround times. Both of these clinical areas were similar in that they were considered to be acute units, requiring rapid result turnaround time. However both areas had significant operational differences with regard to interactions with pathology services.

6.7.2 Process mapping and value stream analysis

The project began by physically mapping the progress of a full blood count request from the taking of a blood sample from a patient (venepuncture) to the production of the electronic or hard copy test result. Every step in the process was recorded and defined on a 'post-it' note before being attached to a physical map on the wall. This process continued for two weeks, by which time the developing process map covered a ten-meter wall space. It became apparent during this period that at least two thirds of the pathology process occurred before the sample ever reached the laboratory.

6.7.3 Test requesting and transportation

During the mapping process I became aware that both A&E and Ward 29 had access to the hospital air-tube system, a highly sophisticated computer controlled system of interconnected tubes linking the entire hospital to pathology. This system allows specimens to be automatically transported to the laboratory via a series of specimen ‘pods’ or plastic capsules. I observed that A&E made full use of this facility however it was also noted (personal diary) that ward staff on A&E did not place a great deal of trust in the system keeping a manual record of all specimens forwarded to the laboratory. In contrast I observed that staff on Ward 29 did not even know that the system existed, even though the access point was within the reception area. Further discussion with ward staff revealed that the system had never even been switched on within this area.

The second key observation that I made highlighted the fact that, although both A&E and Ward 29 had access to the order communication system only A/E utilised this technology while Ward 29 continued to utilise handwritten request forms. In practice within the laboratory I observed that handwritten forms took much longer to process within specimen reception than requests made by the order comm system.

6.7.4 Implications of lean review

Following this work LMR® (2007a) suggested that utilisation of the air-tube and order comm systems by Ward 29 would result in an overall reduction in result TAT from 52mins to 27mins. In essence the laboratory could make 49% improvement in routine FBC TAT simply be utilising systems and software that were already in place within the Trust, and without the need for any significant changes to laboratory automation.

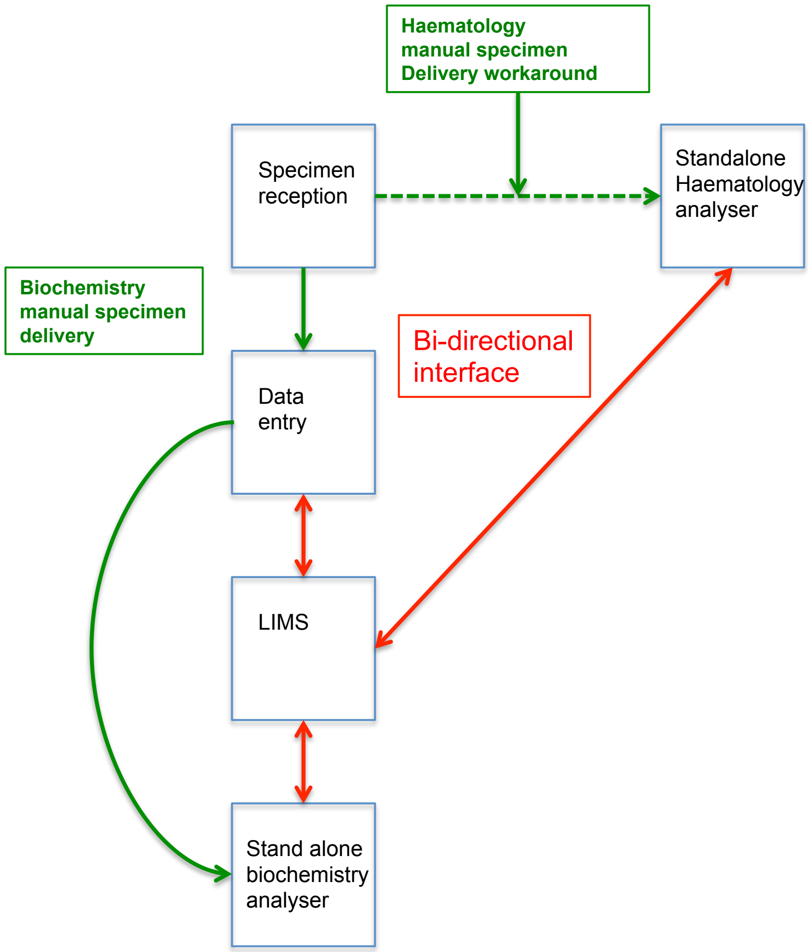
During the latter stages of this project I had a number of follow up meetings with the LMR® consultancy group with regard to the current operations within the laboratory and the potential arrival of the LPSA system. During these conversations the LMR® consultant concluded that they could see 'no significant benefit' (LMR®, 2007b) from purchasing the LSPA system. Changes to working practice at ward level (use of air-tube and order comm system) coupled with some simple changes within the existing layout of the traditional stand-alone automation would more than outweigh the advantages of the LSPA. In essence significant improvements could be made to the pathology process by adopting a socio-technical rather than technologically deterministic approach.

The results of this work made me question the entire decision to select the LSPA system. I discussed my concerns with the clinical director of pathology who although appearing at least sympathetic to my perspective continued with the tendering process. Although I was never given an explanation as to why this should be the case, I assumed that the process information highlighted above was simply gathered too late in the day for a major rethink (personal notes). The primary supplier identified in chapter 6 was awarded the contract and a single-track system (combining biochemistry and haematology instrumentation) as described in chapter 6 was installed during 2009. As predicted the introduction of the tracking system required fundamental changes to the specimen reception and data entry areas as highlighted below.

6.8 Sociomaterial reconfiguration of the pathology laboratory within Organisation X post implementation of LSPA

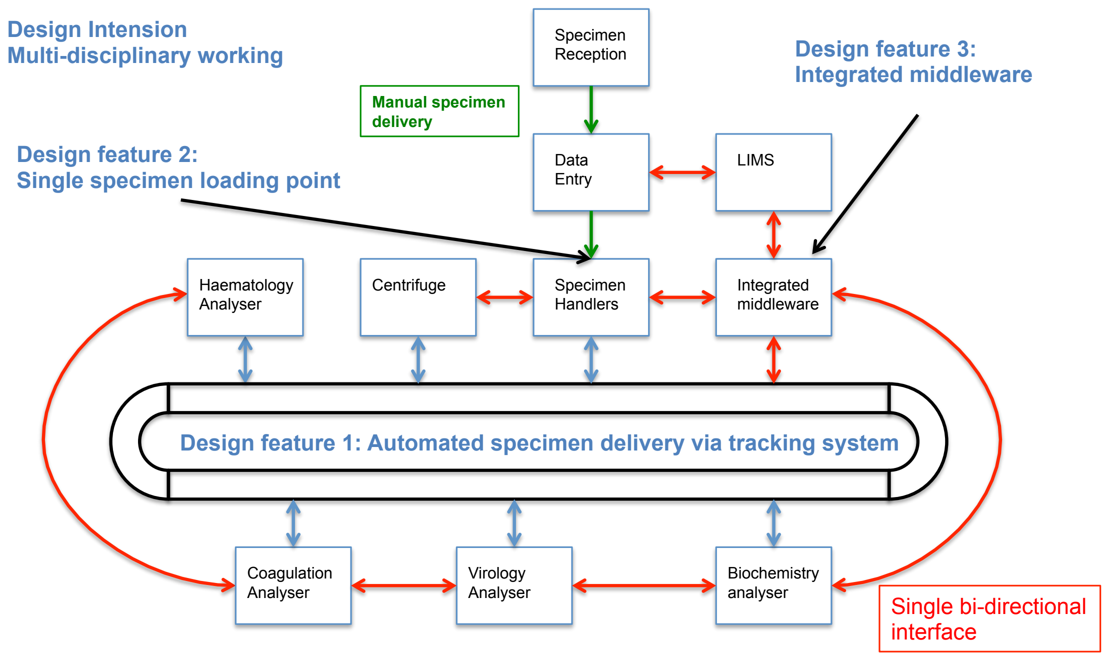
As I observed the traditional working practices within Organisation X, I noticed a common workaround employed within haematology. This workaround involved laboratory staff bypassing the data entry step and placing the individual racks of specimens directly on the haematology analysers, in the knowledge that once analysis had taken place the test results would eventually be linked to the patient demographic information, following subsequent data entry within the LIMS. For technical reasons this workaround was not an option for specimens requiring biochemistry analysis. Hence within the traditional laboratory there were in fact two processes in operation, one for specimens requiring biochemistry analysis and one for haematology as illustrated in Figure 10 below:

Figure 10. Traditional laboratory workaround employed within the haematology department Organisation X.



In practice the introduction of the LSPA system required a change of process (Organisation X, 2008a; 2008b) because the haematology and biochemistry analysers were linked via the single integrated tracking system (Design feature 1) and were no longer manually accessed and loaded. The material properties of the technology required all specimens to be loaded via a central specimen loading point (Design feature 2) from which all specimens were placed on the specimen loaders. The automated specimen loaders could not begin to function until the unique patient demographic and test request information had been downloaded from data entry via the LIMS onto the LPSA integrated middleware (Design feature 3). As a result haematology staff were no longer able to bypass the data entry process and fast track specimens. They were in effect inextricably linked to the process previously adopted by biochemistry via the materiality of the track system. In essence all of the features identified within chapter 6 as being embedded in the design of the instrumentation to facilitate multi-disciplinary (Design intention Multi-disciplinary working) working were having their desired effect, as illustrated in Figure 11.

Figure 11. Multi-disciplinary working imposed on Organisation X as a result of material constraints of the LSPA technology

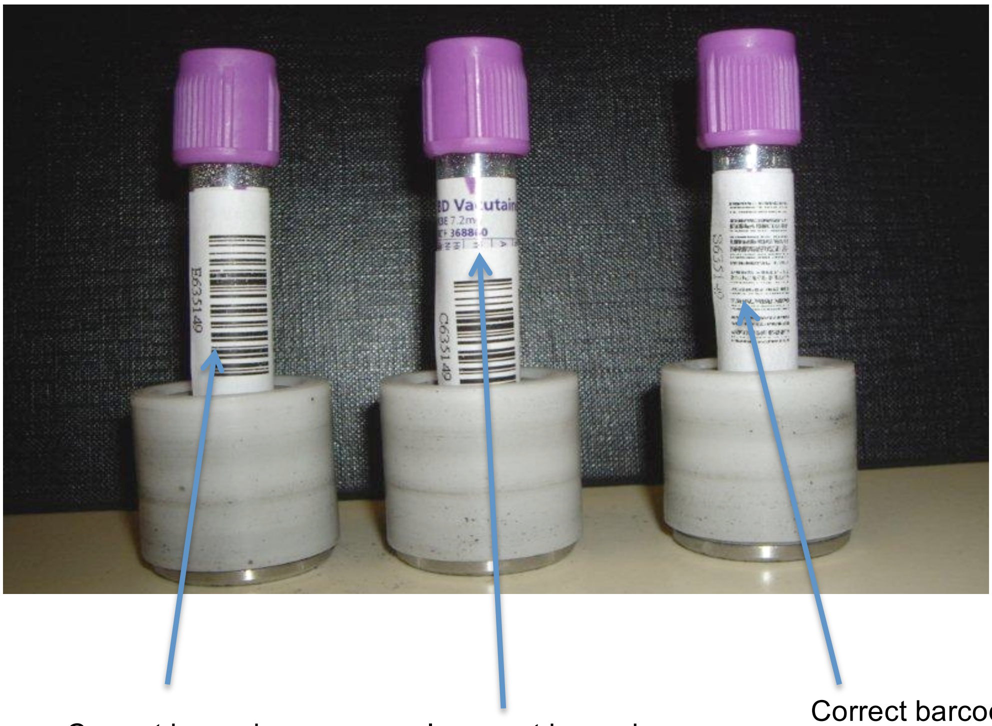


In practice however these material constraints resulted in haematology specimens having to wait in specimen reception until data entry was complete resulting in delayed result turnaround time. The potential to increase haematology result turnaround time by this enforced change in practice was highlighted by laboratory managers during the earlier interviews. For many managers this was the reason why it was predicted that they would select a dual track system, which separated the haematology and biochemistry lines as opposed to the single- track system employed within Organisation X.

6.8.1 Material changes to barcodes

Following the introduction of the tracking system I was also informed of another significant problem concerning the quality of barcodes used to uniquely identify each individual specimen. The success of the entire automated tracking system is totally dependent on the ability to accurately identify each individual specimen via the barcode label at numerous points along the entire automated system. In the traditional process the barcode was simply read once by a single barcode reader at the point of analysis. However with the new system as many as twenty-seven individual barcode readers are positioned along the length of the automated system (Design feature 1 single integrated tracking system) (Design feature 2 Central loading point) (Design feature 3 Integrated Middleware). If any specimen barcode is unable to be read during the process the specimen is rejected by the system. Within the clinical areas ward staff are expected to attach barcode labels on the specimen tubes at a position pre-determined by the laboratory (Organisation X, 2012a). If these labels were placed too low down on the specimen bottle it was obscured by the transport puck and could not be read by the LSPA barcode readers. Additionally poor quality printing of barcodes also created misread problems as illustrated in photograph 4 below.

Photograph 4. Partially obscured specimen barcode (Organisation X, 20012a)



I noticed that in practice laboratory support staff within specimen reception visually checked each specimen for correct barcode alignment (personal notes). In the worst cases I observed that central reception staff were required to re-label the order comm specimens with pre-printed labels manual barcodes, (personal notes). This created a huge amount of additional work and hence delays in the process. I also noted that the re-labelling of specimens introduced a significant clinical risk, in that any errors made during the re-labelling process could potentially result in the wrong test result being assigned to a patient (Shaw, 2009a).

Despite the best efforts of laboratory staff to alert and educate clinical staff (Organisation X, 2012a) as to the problems associated with incorrect barcode labelling an error rate of 30% was identified with order comm specimens, requiring relabeling within the first two weeks of the introduction of the LSPA (personal notes).

In order to assess if this problem still persists I recently contacted a senior biomedical scientist who confirmed that in 2012 three years after the introduction of the LSPA the order comm barcode error rate still ran at approximately 23% (Organisation X, 2012b). The issue has once again been raised to both divisional and Trust management and has resulted in a trust wide alert being issued (Organisation X, 2012a)

6.8.2 Changes to the flow of specimens through the reception area in Organisation X

The requirement to perform data entry prior to placing specimens onto the specimen loaders (highlighted earlier in this chapter) required a comprehensive re-organisation of the workflow and staffing structure within the central reception area.

Following discussion with the LMR® management consultants, it was suggested that, in order to achieve the physical separation required pre and post data input, a system of ‘visual control’ should be employed. Accordingly, I physically demarcated individual sections of the laboratory bench using red and green tape. Prior to data entry I requested that central reception staff placed all specimens requiring data entry into the red area denoting data entry had not occurred. I then requested that all samples should be de-bagged and the data entered one at a time (personal notes). Traditionally specimens would have been de-bagged, and numbered in large batches prior to data input. The new system therefore utilised the 'lean' concept of 'single piece flow' (Shaw, 2008b; 2009b; 2009c; 2010a; 2010b). Once data entry was complete staff were then requested to transfer the specimen into a rack within the green area signifying 'ready to process' (Personal notes).

6.8.3 Changes to staffing structure

In order to facilitate the physical separation of specimens highlighted above I introduced a new support staff role within the laboratory termed 'runner' (Shaw 2007, 2008a). The 'runner' was then utilised to deliver specimens in receipt order to the 'red area' prior to data entry. Following data entry the 'runner' then removed all of the specimens generated from the 'green area' and manually loaded the racks onto the sample loaders prior to processing. Under the new process I requested (personal notes) that the 'runner' should remove all of the specimens generated within a 15-minute period in order to synchronise with the loading and processing capability of the specimen loaders and hence in theory the human/machine was complete (Shaw 2009d, Shaw 2009e).

In addition to the newly created role of the 'runner' other fundamental changes to staffing structure were required. Traditionally scientifically trained laboratory support staff undertook the role of specimen reception and data entry. The department also employed dedicated clerical staff that were only trained to carry out the data entry element of the task. The introduction of 'single piece flow' required the non-scientifically trained clerical officers to undergo a programme of in house training to gain the required scientific skills. In addition both clerical and non-clerical staff were encouraged by laboratory management including myself to undertake formal National Vocational Qualification (NVQ) Level 2 & 3 qualifications in Clinical Laboratory Support, to supplement the in-house training (personal notes). This advanced support worker role was then capable of undertaking some of duties previously undertaken by a biomedical scientist. Staff operating under this extended role was also requested to work 24/7 in order to support the biomedical scientist staff outside the core hours (17:00-8:00) (Shaw, 2008b; 2009b; 2009c; 2010a; 2010b).

At this point in time I also made a suggestion to realign the working hours of biomedical scientist staff in order to match capacity with demand. Essentially this would have required a change in core working hours from 9:00-5:00 to 10:00-20:00. Traditionally biomedical scientist's remuneration for working non-core hours was covered by locally agreed 'unsocial hours' terms and conditions. These payment agreements had been established over decades and accounted for a significant portion of a biomedical scientist's salary. Any changes to working patterns would require significant renegotiation. The issue of resistance to change was so strong that the re-structuring of biomedical scientists staff was never addressed.

6.9 'Mangle of practice' (Pickering, 1995) within the central reception area Organisation X.

The material properties of the LSPA resulted in both a change of working practice and a change in staffing structure within Organisation X. The constraints imposed by the single integrated tracking system (design feature 1) included barcode labelling issues which were never addressed by the laboratory and even now still require approximately 30% of all order comm specimens to be re-labelled. The central specimen loading point (design feature 2) required the physical separation of specimens pre and post data entry and thus required physical changes to be made to the reception process by the introduction of 'single piece flow'. As a result of these changes clerical staff previously employed to undertake data entry duties were developed into scientific support workers.

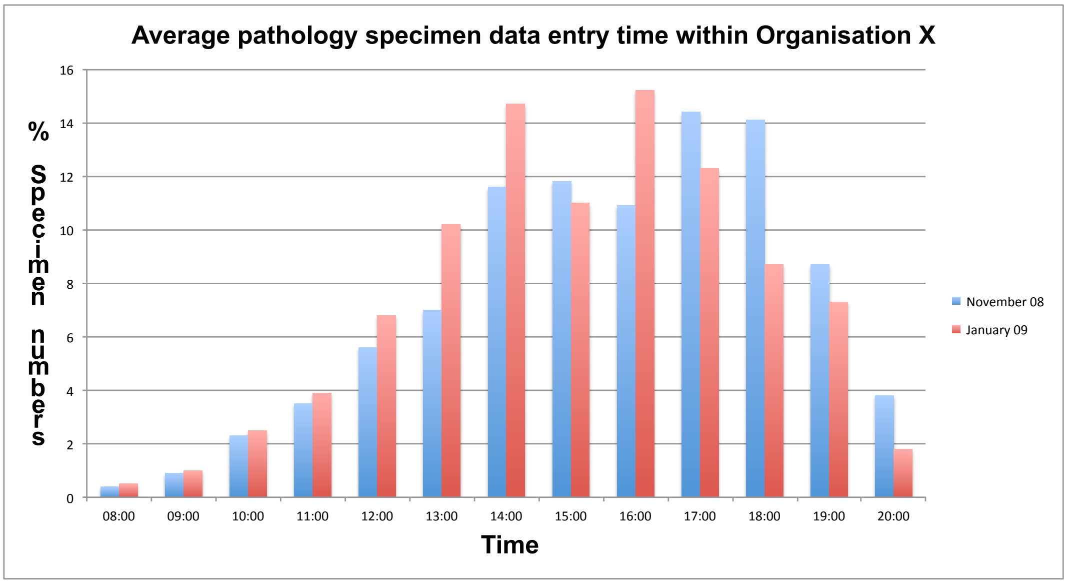
Unfortunately the sociomaterial changes introduced to accommodate the material affordances and constraints of the technology were in practice difficult to maintain. I noted that problems occurred when staffing levels dipped below the recommended minimum levels due to sickness or holiday periods. When this occurred the ‘runner’ was normally the first position to be sacrificed, as the goal appeared to make sure that the specimens were debagged and labelled prior to data entry. As soon as these changes took place staff reverted back to the traditional practice of batching specimens prior to data entry.

I also noted that central reception staff often failed to adhere to the ‘single piece flow’ philosophy and failed to be constrained by the red and green demarcation areas. As a result large numbers of specimens were placed on the specimen loaders without data entry, leading to significant delays in the system because the integrated middleware (design feature 3) was unable to identify the specimen or test request and hence rejected the specimen (personal notes).

The introduction of the LSPA system thus resulted in a ‘mangle of practice’ (Pickering, 1995) within the central reception area. Positive changes (improved staffing levels, adherence to pre and post data entry demarcation requirements, adoption of single piece flow and improved barcode labelling) often resulted in ‘over-performance’ within the reception area. As a result the material constraints of the single integrated tracking system (design feature 1) and central specimen loading point (design feature 2) constrained the process by the physical capacity limitations of the specimen loaders and the number of transport pucks on the track. Negative impacts on the specimen reception area, including reduced staffing level, failure to adhere to pre and post data entry demarcation requirements, failure to adopt single piece flow and reduced quality of barcode labelling created delays or 'under performance' within the reception area. As a result of these delays the LSPA system was under-utilised and hence result turnaround time was increased.

During this period I noted that this 'sociomaterial mangle' ebbed and flowed during the course of the research and at no point was a balance struck between capacity and demand. Graph 1 below highlights the average percentage specimen data entry times during November 08 and January 09. This graph is included to illustrate the delays created during a 'poor' month November 08 when compared to a 'good' month January 09. In November the data entry process continues late into the evening with significant amounts of work being entered after 18:00. In contrast there is a significant reduction in data entry after 18:00 during January 09.

Graph 1. Average pathology specimen data entry time within Organisation X, November 08 and January 09



The inclusion of Graph 1 in no way illustrates the ‘chaos and confusion’ (personal notes) that can arise when a complex system like the one described above fails. This period was truly difficult time for both staff and management as every day appeared to present new challenges. Unfortunately it is impossible to represent those emotions and frustrations in text. The effect of delays in specimen reception did however have two sociomaterial implications. Firstly, during this period, I noticed a common workaround employed by support staff to cope with urgent STAT specimens entering the laboratory. Upon receipt STAT specimens were not fed through the automated route via the specimen handlers. Instead these specimens were manually loaded directly on to the front of the analysers, very much as they had been within the traditional process. In essence the workaround for STAT specimens bypassed the LSPA technology entirely. Secondly the ‘mangle in practice’ (Pickering, 1995) described which resulted in significant delays within central reception played a significant role in the decision to remove blood coagulation analysers from the tracking system altogether (Personal notes).

6.10 Summary

In addition to outlining the influence and perception of managers involved with the purchase of LSPA this chapter has highlighted the ‘mangle of practice’ (Pickering, 1995), which develops on a micro scale following implementation. The material constraints of the single integrated tracking system (Design feature 1), central loading point (design feature 2 and integrated middleware (Design feature 3) required changes to both working practice and staffing structure within Organisation X. Within this mangle constant modification of both the technical and social elements of the entire laboratory were required to optimise performance. These changes were a constant feature of the new working environment where a re-evaluation of working practice was followed by an evaluation of performance and subsequent modification. The following chapter will highlight the use of a similar LSPA system within another different Organisation Y. The aim of this research will be to identify how the material affordances and constraints of the technology together with other social processes such as the influence of management and management consultants affected working practices across organisational boundaries.

Chapter 7 The Sociomaterial impact of LSPA in Organisation Y

7.0 Introduction

The previous chapter highlighted the ‘mangle in practice’ (Pickering, 1995) that arose on a ‘micro’ level following the introduction of LSPA within Organisation X. This chapter will focus on the ‘mangle in practice’ (Pickering, 1995) that occurred on a ‘macro’ scale following the implementation of similar technology in Organisation Y. Initially this work will focus on the transfer of knowledge that occurred when the researcher moved from Organisation X to Y. This chapter will identify how the material affordances and constraints of the LSPA technology together with other social processes, such as the influence of management and management consultants, affected the homogeneity of working practice across organisational boundaries. Secondly this chapter will highlight how the sociomaterial entanglement, which developed in organisation Y, influenced the decision not to centralise laboratory services within the pathology modernisation agenda.

7.1 Overview of Organisation Y

Situated in the North East of England Organisation Y is one of the largest hospital and community providers in the NHS, serving a population of around 600,000. Service provision is primarily provided in one of three sites, which for the purposes of this research are termed urban 1, urban 2 and rural. Opened in 2001 via a Public Funding Initiative (PFI), urban 1 is a major acute hospital providing services to a population of more than 250,000. The hospital provides emergency trauma, surgery and specialist services in dermatology and plastic surgery. In contrast urban 2 was originally constructed in 1933, although most of the current infrastructure dates to the late 60’s. Urban 2 is owned and managed by Organisation Y and serves as the main trust headquarters. The hospital provides major acute and outpatient services to a population of approximately 130,000. Rural hospital was opened in 2002 again as part of a PFI. Serving a population of approximately 120,000 it provides a specialist rehabilitation services, as well as acting as a centre of excellence for low risk hip and knee replacement operations. In 2011 the hospital ceased to offer full A&E services, acting instead as a GP led urgent care centre.

7.2 Technological change within Organisation Y

In 2007 the pathology laboratory within Organisation Y undertook a programme of work to replace the majority of equipment as part of a MSP with the same primary supplier as Organisation X. According to the business case produced at the time, the attraction of moving to a MSP was primarily financial, 'single contracts providing common analysers and reagents across the three sites will provide savings in in the order of £100,000' (Organisation Y, 2007). As had been observed within Organisation X, the vast majority of these cost savings were to be made via the provision of a MSP and the associated VAT reclamation of such an undertaking (Organisation Y, 2008a).

In contrast to Organisation X, Organisation Y had opted for a dual tracking system within haematology and biochemistry (Organisation Y, 2008b). Both the urban sites utilised essentially the same single track as described in the previous chapter within Organisation X minus the haematology and coagulation instrumentation. Thus the biochemistry system in both urban 1 & 2 operated with the same specimen loaders, robotics, automated tracking system and on-line centrifuges as described previously. The separate haematology track was however supplied by a third party and not the primary supplier.

7.3 Knowledge transfer from Organisation X to Y

In early 2010 I gained employment within Organisation Y as Lead Biomedical Scientist in Haematology and Blood Transfusion. Upon commencement of employment within Organisation Y I was initially given the task of reviewing haematology services across all three sites. Senior management were aware from the interview process (Shaw, 2009f) that the researcher had experience of adopting LEAN methodology within the central reception area of Organisation X and was hence given the opportunity to apply the same principles within Organisation Y. The focus of this work became the reception area of urban 2, which was having significant difficulties managing capacity and demand through the automated platforms. This was leading to significantly delayed result turnaround times especially within biochemistry (personal notes).

7.4 Changes to the working practice within Organisation Y

Traditionally within Organisation Y haematology deployed the same workaround (Haematology Manager, Organisation Y, 2010) as had been observed in Organisation X, whereby specimens were placed directly on the analysers prior to data entry. As before the biochemistry department could not utilise this workaround for technical reasons.

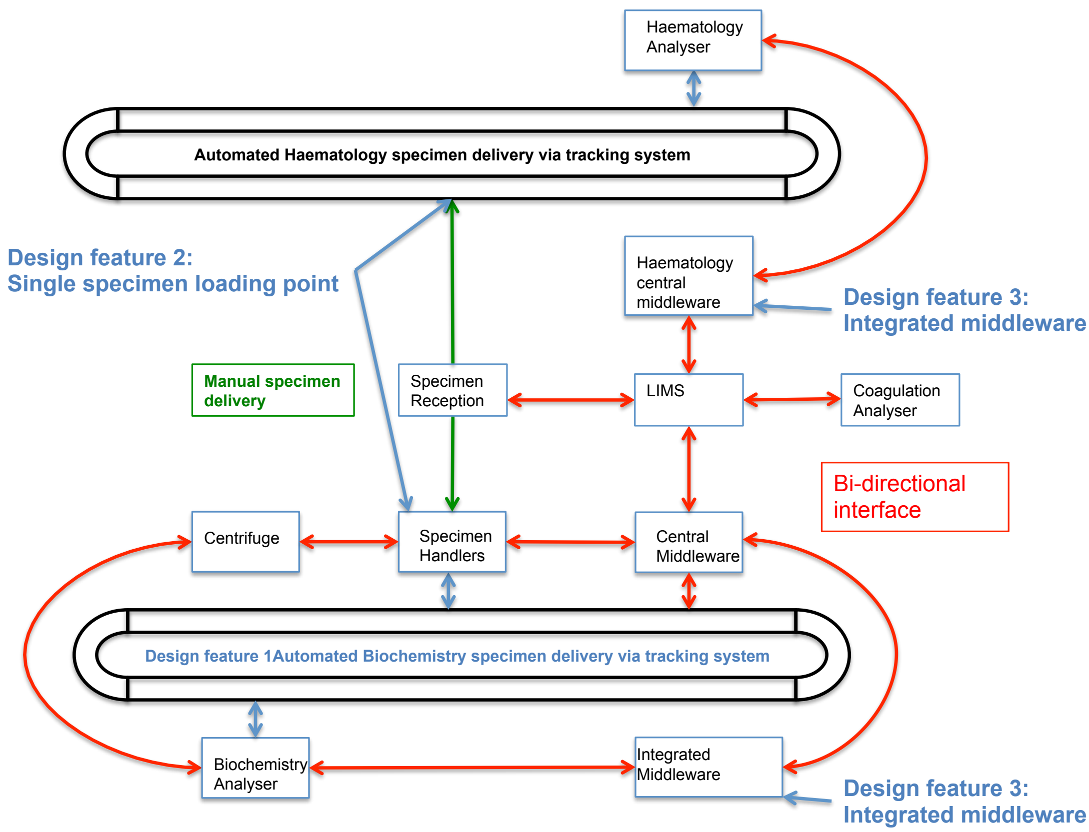
From my observations in practice (personal notes), the introduction of the LSPA system within Organisation Y imposed the same material affordances and constraints that had been observed in Organisation X. Within Organisation Y both the haematology and biochemistry analysers were now linked to their own individual integrated tracking system (Design feature 1). As a result they could both no longer be accessed individually and loaded manually as had been the case within the traditional system. The material properties of the technology required all specimens to be loaded via one of two central specimen loading points (Design feature 2) from which all specimens were passed to either the specimen loaders in the case of biochemistry or directly to the analysers in the case of haematology. Neither the automated specimen loaders nor the haematology analysers could function until the unique patient demographic and test request information had been downloaded from data entry via the LIMS onto the LPSA integrated middleware (Design feature 3). In essence all of the features identified within chapter 5, as being embedded into the design of the instrumentation to facilitate multi-disciplinary working were constraining the process and creating significant delays within the specimen reception and ultimately delayed result turnaround time.

The decision to select a dual rather than single-track system meant that the departments of haematology and biochemistry operated as separate entities. As a result, within Organisation Y, the primary supplier design intention of multi-disciplinary working was not being achieved.

In respect of my primary research question, i.e. to investigate how do the material affordances and constraints of LSPA affect working practices across organisational boundaries, this is significant. In practice the material affordances and constraints of the three primary design features employed to facilitate multi-disciplinary working namely integrated tracking systems, central loading points and integrated middleware, were affecting the homogeneity of working practice across both of these sites.

A diagrammatic representation of the dual tracking system within Organisation Y is highlighted in Figure 12 below:

Figure 12. Organisation Y dual tracking system



In order to address the problem of delays in data entry and hence prolonged result turnaround time, I formed a small team of central reception staff to work on the production of current and future state process maps (Organisation Y, 2010a; 2010b). Subsequently a larger focus group of reception staff were gathered to review the current situation and future state plans. The material constraints of the LSPA technology identified above required all specimens to undergo data entry prior to analysis. Staff highlighted that there was a 'lack of standardisation' (Organisation Y, 2010c) within the specimen reception process. During this review it became apparent that, just as in Organisation X, central reception staff within Organisation Y (personal notes) undertook designated roles without necessarily considering the impact or repercussions on the rest of the process. In essence just as within Organisation X, central reception staff within Organisation Y split the roles of specimen reception (de-bagging and demographic checking) from that of data entry. As a result delays in data entry created a huge backlog of specimens, which could not be processed because of the material constraints of the LSPA as identified above.

7.5 Influence of management consultants

During this period of research, the primary supplier of both Organisation X and Organisation Y had formulated the HCS team identified in Chapter 5. The delays in specimen reception created by the constraints of the LSPA automation were so significant I decided to contact the HCS team for some process management support as no one within Organisation Y apart from the author/researcher had any previous experience of ‘lean’ methodology. With regard to homogeneity of working practice across both Organisation X and Organisation Y my own personal involvement in the change process and knowledge transfer is significant.

The HCS team and I then began what was to become a two-week comparative study of both urban 1 & 2 in order to scope the scale of the problem. Within urban 2 it came as no surprise to me that they regarded the delays within the central reception area as ‘dire’ (HCS, 2010). A collaborative recommendation was therefore made between myself and the HCS team (personal notes) to both standardise working practice and introduce a system of ‘single piece flow’ (HCS, 2010) within the department. The new system would, as previously noted, be based on an individual member of reception staff being given the responsibility to fully process (de-bag and data entry) a single specimen at a time. The introduction of a ‘runner’ (personal notes) would once again be utilised to collect all available specimens every fifteen minutes once data entry had been completed. Once again red and green areas of bench were demarcated to facilitate the separation of specimens pre and post data entry. I also requested that the ‘runner’ remove specimens from the green area; designating data entry had occurred, every fifteen minutes. The fifteen-minute collection cycle was again time constrained by access to the central specimen loading point on the specimen handlers (Design feature 2).

These changes to working practice were the same changes that had been introduced with limited success within Organisation X. On reflection it is perhaps unsurprising that the ‘mangle of practice’ (Pickering, 1995) created within Organisation X was simply transferred to Organisation Y.

In addition to the suggested changes to working practice, the primary supplier HCS team also highlighted that poor order comm barcode quality and a failure to apply the barcodes correctly within the clinical areas was once again creating problems. Just as had been observed within Organisation X, 30% (Primary Supplier, 2011a) of order comm specimens received within the laboratory required re-labelling, introducing the same delay and clinical risk as had been identified previously within Organisation X.

The HCS team also noted that Organisation Y separated urgent STAT specimens from non-urgent (Primary Supplier, 2011a). Within Organisation Y urgent specimens were centrifuged manually and processed directly on the instruments, rather than being allowed to progress through the fully automated route. In this respect the technological constraints of the automated system were overcome by the same workaround as had been observed in Organisation X.

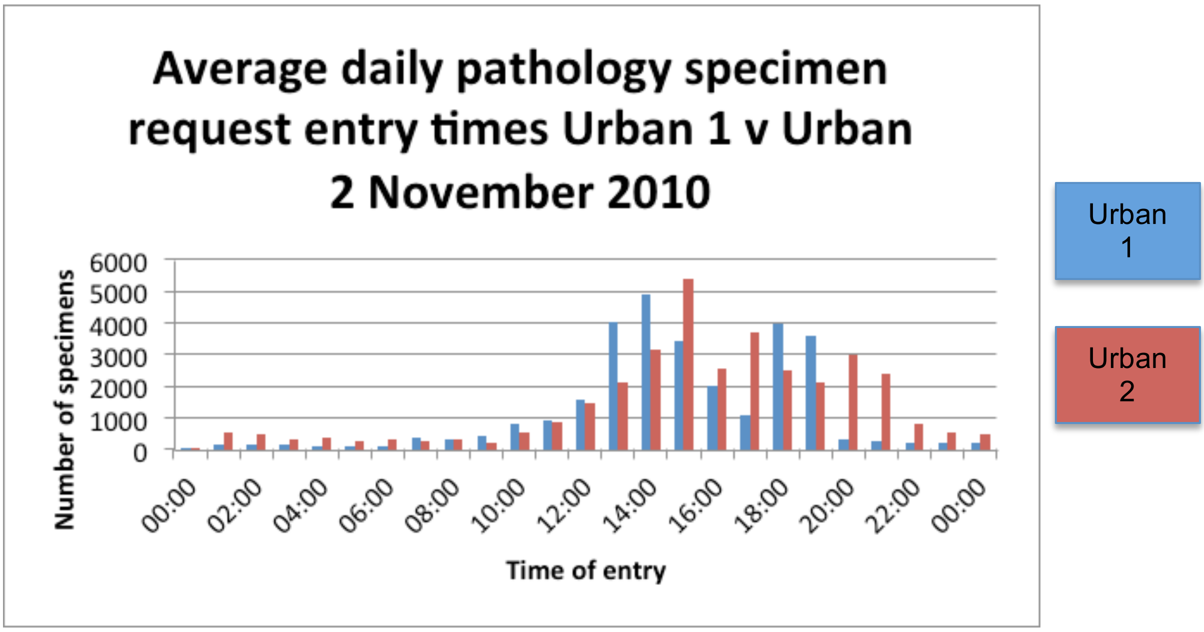
Just as within Organisation X, reduced staffing levels, failure to adhere to pre and post data entry demarcation requirements, failure to adopt single piece flow and reduced quality of barcode labelling within Organisation Y resulted in 'under performance' within the reception area. Underperformance could easily be assessed visually by of the huge backlog of specimens awaiting data entry. Conversely adherence to the strict demands of the lean process resulted in periods of 'over performance' within the central reception whereby racks of specimens having undergone data entry would be stacked in front of the specimen loaders awaiting processing.

As stress levels in the department rose working relationships broke down on a daily basis (personal notes). In the words of the ever positive and highly receptive central reception manager it was a case of 'tears and tantrums' (Reception Manager, Organisation Y, 2010) every day.

Despite allowing time for the new system to become embedded into routine practice, tensions remained high for six months and eventually the situation reached crisis point.

Graph 2 highlights the comparative difference in data entry time between the new 'lean' process at urban 2 and the traditional specimen reception process in urban 1 (where no change had been made and workload and staffing levels were approximately the same). During November 2010 a significant proportion of the daily workload within urban 2 underwent data entry onto the LIMS between 20:00 and 22:00. These delays were so significant that the integrity of the patient results came into question due to specimen deterioration.

Graph 2. Average daily pathology specimen request entry times Urban 1 and Urban 2, November 2010.



7.6 Sociotechnical modifications to working practice within urban 2

During November 2010 I arranged a formal review with staff and union representatives to assess the situation. During this meeting it was identified that stress levels were high and that fundamentally the group were 'not working as a team' (Organisation Y, 2010d; 2010e)

At the beginning of this project I had stated to staff that this change management programme would not be imposed and that if modifications were required we would decide this as a team. During this meeting I conceded that disappointingly the 'lean' project had failed to achieve the desired effect and a fundamental change was required.

The group therefore decided on the following plan of action (Organisation Y, 2011a):

• Review space/staff/workload balance
• Revert back to the dual process of specimen reception and subsequent data entry instead of ‘single piece flow’
• Initiate telephone divert to reduce interruptions
• Benchmark working practices with those at urban 1
• Introduce change as slow continuous improvement rather than ‘big bang’
• Review the urgent bench

Although these concessions were made, it was agreed to work to a set of minimum specified criteria in line with a sociotechnical approach. The minimum criteria set by staff themselves were as follows (Organisation Y, 2011a)

• Work to a standardised process
• Maintain a rota to direct staff during the working day
• Aim to process 60 specimens a minute every 15 minutes in line with the constraints imposed by the automated platform
• Maintain a flow of specimens

The effect of the above changes, which I considered at the time to be a slightly less structured adaptation of the process changes that I had originally suggested, had an almost immediate positive effect (personal notes). Stress levels appeared to reduce and there was a ‘significant improvement in working relationships’ (Reception Manager, Organisation Y, 2011). Productivity within the central reception area also improved with the revised changes to process as suggested by staff themselves. It appeared to me that the adoption of an essentially sociotechnical approach, rather than the technological determinism decreed by lean manufacturing principles were in this environment much more acceptable to staff. A subsequent review of the project by the HCS team as part of their annual health check acknowledged that significant improvements had been made (Primary Supplier, 2011a) and that performance levels of the central reception area within urban 2 subsequently matched that of urban 1 (Primary Supplier, 2011a).

7.7 Formal interaction with the primary supplier to influence the staffing structure within Organisation Y

During the course of this research my relationship with the primary supplier HCS team began to develop. The HCS team began to show an interest in my research, with regard to changes in laboratory staffing structure via the interview process, highlighted in chapter 5. As identified in Chapter 5 the HCS team themselves were often asked for advice on appropriate staffing structures by user organisations, especially with regard to potential changes in skill mix. As highlighted in Chapter 6, pathology managers within the UK were also interested in the potential to utilise support staff to undertake the tasks traditionally undertaken by biomedical scientists. Senior management colleagues within Organisation Y and I were then approached by a senior member of the HCS team to contribute to an extensive project to evaluate the current and potential staffing structures utilised within the laboratory. As a result of this work the primary supplier HCS team, in conjunction with senior managers from Organisation Y, produced a collaborative model highlighting potential skill mix changes following the introduction of LSPA as illustrated in Table 20 below:

Table 20. Overview of current and potential staff banding following analysis by Organisation Y and primary supplier management staff (Primary Supplier, 2011b)

Manual task	Current average Agenda for Change (AfC) staff grade	Potential Agenda for Change (AfC) staff grade
Pre and post analysis	2.7	2.5
Analysis	6.0	4.1
Administrative	2.5	3.0

Within the context of this research, I have included the above information to support my claim that the designers of LSPA technology certainly did want to influence or be in a position to influence staffing structures within laboratories.

This collaborative work however did more than just consider the staffing structure within Organisation Y. Following discussions with senior management, the HCS team and I were aware of the intention to review pathology services within Organisation Y across all three sites. The HCS team then suggested they would be very willing to review capacity, demand and productivity across the entire pathology process. Following this initial analysis, the HCS team became further involved in the departmental reconfiguration discussions being undertaken in Organisation Y. Although the issue of reconfiguration will be addressed in the following section of this chapter, primary supplier involvement at this stage further illustrates a willingness to shape the working practices of the user organisation. This work was done in collaboration with Organisation Y and the support given by the primary supplier contributed significantly to the forward planning and subsequent rationalisation strategy of Organisation Y. This analysis included a review of GP specimen referral patterns and relative demand from each GP practice, together with an assessment of logistics for specimen transportation and in depth capacity and demand modelling. As such this work represents a significant bridge between design and use of LPSA technology.

7.8 Macro 'mangle of Practice' (Pickering, 1995) - Service transformation of Organisation Y

During October 2010 senior managers including myself from the haematology, biochemistry and microbiology departments within Organisation Y undertook a strategic review of pathology services. The aim of this work was to review the potential to centralise pathology services on one of the available sites within Organisation Y (Shaw, 2010b). This review was undertaken primarily in response to both internal and external pressures including 'pathology modernisation' and increasing cost improvement targets as a result of the UK Government Quality Innovation Productivity and Prevention (QIPP) agenda (Shaw, 2010b). On reflection it could be argued that the UK government pathology modernisation agenda was regarded as a threat rather than an opportunity within Organisation Y.

At the same point in time the N.E.Path network, which included Organisation Y was already beginning to instigate a major rationalisation, programme of its own.

In July 2010 the N.E.Path modernisation group released a document, which highlighted that in their opinion current service provision for pathology laboratory services within the North East of England, was not in the best position to meet the financial targets set by the UK Government as highlighted below:

'from the Department of Health to individual consultants and laboratory managers, all are drawn to the following conclusion. While history suggests we can achieve 2.5% budget cuts in our current configuration, we cannot do this on a sustained basis going forward, let alone at a targeted figure of 5-7%, year on year' (Drury, Bottoms and Gibson, 2010)

'*Between now and late September a paper (a Strategic Outline Business Case) will be produced for presentation to the Foundation Trust (FT) and Primary Care Trust, Chief Executives of the North East, for them to consider the adoption of a 'shared-service' model. A huge amount of detailed work will then need to be carried out over the subsequent 12-24 months to shape and implement the transformation' (Drury, Bottoms and Gibson, 2010).*

N.E.Path considered then that the required cost savings estimated to be in the region of £20-50 million (Drury, Bottoms and Gibson, 2010) could only be made by the centralisation of services via a 'shared service model' (Drury, Bottoms and Gibson, 2010).

The opportunities available to Trusts as a result of consolidation were expressed as follows (N.E.Path, 2010a, p.4):

• Improved utilisation of skilled staff across the region, including the ability to support comprehensive training

• 24 hour senior clinical staff cover becomes more sustainable

• Consolidation of analytical platforms to reduce costs

• Workload sharing to accommodate surges in demand

• Risk sharing and improved business continuity

• Greater harmonisation of methods to benefit clinical end users.

As a result of this work it was forecast that savings of approximately £22.66 million could be made over a 4-year period, £12.8 million of which would be composed of staff savings and £5.1 million due to reduced overheads. These savings were compared at the time to a predicted saving of £8 million if the status quo was maintained locally within Trusts (N.E.Path, 2010a).

7.9 Centralisation of services within Organisation Y

The management group within Organisation Y including myself were then faced with a significant dilemma, should we centralise services internally in order to meet the required cost savings or do we join forces with the regional network. As highlighted in the previous chapter pathology managers within the North East region appeared happy to consider regional rationalisation as long as their own organisation was considered a 'hub' in the process rather than a 'spoke'.

Within Organisation Y this would also appear to have been the case as highlighted below:

> *'Although the network is holding talks on regional configuration to meet the QIPP target, it is acknowledged that the needs of the Trust, in particular financial issues, are dealt with as a priority' (Organisation Y, 2010f).*
>
> *'Early talks have centred on the consolidation of 'cold' GP work within the region which would have a major financial impact on direct access income for* Organisation Y *with some 60% of the entire pathology workload coming from primary care. The continued provision of acute services at* Urban 1 *and* Urban 2 *means staffing levels would need to be maintained in order to provide a 24/7 'hot lab'. The Modernisation group have also discussed the possibility of reducing regional pathology overheads (Human Resources, Finance, IT and logistics) but it is difficult to see how this would be achieved if* Organisation Y *was assigned as a spoke and not a hub' (Organisation Y, 2010f).*

The management group within Organisation Y including myself contributed to three focus groups during this period to consider the alternatives. As a result of this work four internal review documents were produced (Shaw 2010c, Organisation Y, 2010d; 2011b; 2011c) each highlighting the fact that all three individual sites within Organisation Y appeared to have their own affordances and constraints with regard to centralisation of pathology services. Essentially none of the three available sites was considered to be an ideal candidate for centralised pathology services. Urban 1 simply appeared to lack the 'physical space' (Shaw, 2010c) to accommodate centralised services without significant cost. Urban 2 physically appeared to be a better proposition; however there was clinical resistance (Shaw, 2010c) to utilise this site and certain physical challenges with regard to the out-dated infrastructure. Although the rural site could also not physically accommodate the entire pathology service it did however offer strategic advantages because of its 'geographical location' (Shaw, 2010c).

With regard to this research particular attention must be paid to the impact of the wider material affordances of the technology and the contractual relationship with the primary supplier.

7.9.1 Centralisation of the automated tracking systems

As stated previously I considered the organisation of pathology services within Organisation Y to be unique in that both urban 1 and urban 2 are equipped with the same dual tracking systems for haematology and biochemistry i.e. four tracks in total. During the review work undertaken by myself in collaboration with the primary supplier HCS team, it was calculated that from a capacity and demand perspective the LSPA technology on one of the urban sites could accommodate the entire workload of Organisation Y, with only minor changes to the working patterns of staff (Primary Supplier, 2011b). In light of this significant affordance it therefore made sense to consider centralising pathology services on one of the urban sites. However this significant material affordance was countered by three sociomaterial constraints observed in practice.

7.9.2 Physical constraints

From a material perspective the automated tracking systems are huge pieces of kit, which require substantial infrastructure changes to operate including dedicated water supplies and associated plumbing etc. Centralisation of a single automated platform onto the rural site would in practice not be an easy or cheap option.

7.9.3 Constraints imposed by the MSP

Another option that I considered during this period was the physical removal of one of the LPSA systems from either urban site. Although LSPA is considered within the context of this research to be a relatively ‘fixed function technology’ (Orlikowski, 1996) modifications to the system can be made if pieces of equipment are not used or removed altogether. The introduction of LSPA equipment was however introduced as part of a ten year MSP. As such Organisation Y was constrained by the MSP contract itself, as significant changes such as the removal of an entire system, although theoretically possible, would have to be negotiated with the primary supplier.

7.9.4 Reliability and ease of use of the LSPA technology

As highlighted in Chapter 6 the design intention of the primary supplier with regard to LSPA was to facilitate multi-disciplinary working. The embedded design features (single integrated tracking system, central specimen loading point and integrated middleware) were intended to reduce overall staff numbers and facilitate skill mix changes. However in practice I noted that the complexity of the instrumentation and the unreliability of particular pieces of technology caused concerns. During this period a number of serious untoward incidents were recorded within the biochemistry department. One of these incidents occurred as a direct result of technological breakdown and the other a result of human error on the part of a member of the biomedical scientist staff operating the equipment. As a result of these incidents senior managers within the biochemistry department were not confident to allow support grades of staff to operate the LSPA technology unless under supervision from a biomedical scientist (Lead Biomedical Scientist Biochemistry, Organisation Y, 2012). This lack of confidence in the equipment had serious implications with regard to the potential to implement skill mix changes and reduce staff numbers.

In essence the sociomaterial constraints of LSPA technology within Organisation Y were hindering laboratory centralisation, despite this being considered a key affordance by UK pathology managers as highlighted in the previous Chapter 6.

7.10 Influence of Pathology modernisation

During December 2010 I was invited to attend a workshop arranged by N.E.Path along with a number of senior pathology managers from the North East region. The N.E.Path network manager chaired the workshop. This meeting took place during one of the worst winters in living memory and therefore was poorly attended by managers north of the region. This fairly unrepresentative group were then asked to comment on a number of topics including the 'objectives of the network', 'critical success factors' deemed essential to the project. The group were also asked to review a number of potential service models based on 'hub' and 'spoke' configurations (Shaw 2010d). Within this context a 'hub' laboratory would be a large-scale centralised service providing the complete repertoire of pathology tests. Conversely 'spoke' sites within this model would only provide 'hot' or acute services for the hospitals in question, which in reality meant acute in-patient services only. All 'cold' non-urgent GP work and specimens obtained from outpatient clinics from 'spoke' sites would be referred to the 'hub' for processing.

On the 10th December 2010 N.E. Path released version 1.0 of a Strategic Outline Case (SOC) (N.E.Path, 2010b) which highlighted a 'long-list' of service delivery models highlighted below in Table 21:

Table 21. Long-list of service delivery models produced from the output of N.E.Path service manages workshop Dec 10 (N.E.Path, 2010b)

Long-list Option Number	Description
1	Do Nothing
2	All core work done in hospital labs – consolidation only in some specialist services
3	Discipline specific consolidations
4	
4a	One hub – numerous spokes – all work
4b	Two hubs (identical) – all work
4c	Two hubs (complimentary) all work
5	
5a	One hub – plus spokes – direct access and hospital cold work only
5b	Two hubs – plus spokes – direct access and hospital cold work only (identical) – all work
6	
6a	One hub – plus spokes – direct access work only
6b	Two hubs – plus spokes – direct access work only (identical) – all work

Version 0.1 of the SOC (N.E.Path, 2010b) also contained a scoring matrix based on a number of options including 'scope' and 'scale' of the new service, which were to be evaluated against a number of 'critical success factors'. The composite scores would then be used to evaluate each service model until a preferred option was selected.

The pace of change within the modernisation initiative is reflected in the rate of development of the SOC. Within a 41 day period a further four versions (N.E.Path 2011a, N.E.Path 2011b, N.E.Path 2011c, N.E.Path 2011d) were released, each containing often subtle changes to the 'long-list' (N.E.Path 2010b) of service model options. A modified version of the amendment history is highlighted below in Table 22:

Table 22. N.E. Path SOC Amendment History (N.E.Path, 2011f)

Version	Date	Amendment History
0.1	10/12/10	Initial draft following first workshop
0.2	06/01/11	Updated based on feedback from workshop attenders
0.3	16/01/11	Updated following second workshop
0.4	18/01/11	Updated with initial feedback from N.E. Path management
0.5	01/02/11	Updated based on feedback from workshop attenders

I attended a further two meetings during January and March 2011 in order to assess progress and hopefully contribute to the change process. At no point, however, was I asked to score any of the above options and I personally felt very disengaged from the whole process. One very frustrating feature of these meetings was the fact that they never appeared to have any continuity with regard to attendees (personal notes). Another significant feature of all three of these meetings was the fact that very few, if any members of the clinical teams were in attendance (personal notes).

Within Organisation Y there was a great deal of clinical opposition to the whole scoring process. In a personal communication the then Clinical Director of pathology commented ‘how a random set of non-mandated delegates can score an issue of such profound significance is breath-taking’ before adding ‘what authority does this meeting have to score anything’ (Organisation Y, 2011d).

By September 2011 the N.E.Path management team had developed the SOC into an Outline Business Case (OBC) (N.E.Path, 2011e) which revealed the following:

> *‘high level findings show strong support for a single management structure, which would provide significant quality benefits and facilitate the move to a three hub / multi-spoke model generating substantial savings of an estimated £162m over a ten year term’.*

At this stage there was no inference as to where the three ‘hubs’ would be situated.

Senior clinicians within Organisation Y raised objections criticising the modest scale of the proposal. Principal concerns revolved around why the three-hub model had been selected above a two or even one hub model (Organisation Y, 2012a; 2012b).

The OBC (N.E.Path, 2011e, p.67) also assumed that ‘a Foundation Trust’ would host the Network. This single Trust would then hold ‘contracts and service level agreements with the other acute Trusts, GP consortia and other third party commissioners/service users as needed'. No inference was given at the time, as to which Trust would take on the lead role.

All Trust CEO's were invited to a presentation with the N.E.Path board members towards the end of 2011. A justification paper (N.E.Path, 2011f) was produced by N.E.Path management for the event, which highlighted the expected cost savings:

> *'consolidating the existing configuration of pathology services in the North East of England, are estimated to be between £1.5-2.0 million per Trust, with total savings of between £150-200 million over the coming 10-year period' (N.E.Path, 2011f).*

Rather than accept the OBC on face value the Trust CEO's asked the N.E.Path board for a 'detailed review of the baselines and confirmation of the configuration of the hub/spoke model' (N.E.Path, 2012a).

In February 2012 the N.E.Path group produced a draft version of the Full Business Case (FBC) (N.E.Path, 2012a) which highlighted on-going tensions. This document revealed that the largest NHS Foundation Trust in the North East of England had 'withdrawn from the project' but would 'remain part of the network' (N.E.Path, 2012a).

In conclusion this document once again requested the remaining Trust CEO's 'support to move to phase 2 of the FBC' together with a requirement to establish a 'formal programme board'. It was also recognised that this was a significant change programme and it was 'inevitable that some in pathology will be concerned about the scale and pace of change' (N.E.Path, 2012a).

An indication that Organisation Y was also developing its own rationalisation plans, which could potentially mean withdrawal from the N.E.Path network were relayed to the network board during April 2012 (N.E.Path, 2012b).

In May 2012 political tensions were also running high as the CEO of Organisation X, who was also at the time the CEO of N.E.Path, decided to resign from both posts. During the interim period a new CEO from a Trust in the north of the region was appointed as lead for the network.

Within the context of this the production of multiple versions of SOC, OBC and finally draft FBC were considered to be boundary objects moving backwards and forwards across the organisation boundaries of network management and individual Trust CEO and pathology managers. Each time they cross an organisational boundary they take on a new form, constantly manipulated and adapted in practice.

7.11 Managerial restructure within Organisation Y

During late 2011 Organisation Y underwent a complete managerial restructure including a change of CEO. As part of this re-structure I applied for and attained the role of Head of Diagnostics, which meant being managerially in charge of pathology.

In order to inform the new executive team on the options for reorganisation of pathology services within Organisation Y, I was asked to produce a briefing paper to present to the newly formed Executive and Clinical Leaders group. The overall aim of this document was to suggest 'the most clinically appropriate, cost effective and efficient model available to the Trust in order to support service delivery' (Organisation Y, 2012c).

In order to shape Organisation Y into the suggested ‘hub’ (Organisation Y, 2012c) model, three options were proposed as follows:

1 Do Minimum – No major changes to service provision centralise cold work where appropriate
2 Centralise all ‘cold’ work including Microbiology onto the urban 1 site
3 Centralise all ‘cold’ work including Microbiology onto the urban 2 site.

Although not highlighted in this internal document the fourth option available to Organisation Y was to form a ‘hub’ or more likely a ‘spoke’ within the N.E Path Network.

During this presentation I highlighted the sociomaterial affordances and constraints of the above options. In particular the physical limitations of the infrastructure across all three sites, the constraints of the primary supplier MSP with regard to modification to technological platform, and the associated constraints imposed on changes to skill mix (Organisation Y, 2012c) were discussed. I went on to suggest that modest rationalisation of service could release savings in the region of £400K (option 1). In essence rather than shape Organisation Y to fit the network ideal of a single ‘hub’ laboratory as decreed by the pathology network, more savings could be realised by adopting a collaborative approach to change, where rationalisation would be based on clinical need rather than political impetus.

7.12 Executive involvement in change process

Following this presentation the newly appointed CEO addressed all pathology staff to review the current internal situation with regard to pathology services and the threat/opportunity of rationalisation via N.E.Path. During this very frank discussion the CEO stated the following:

> *'pathology is already a highly efficient integrated 'hub' the shape of which needs to match the clinical requirements of the Trust not the Network'. 'Continued appropriate rationalisation of service to meet clinical requirements would appear to be the least disruptive to staff, most cost efficient and capable of providing a significant increase in quality' (Organisation Y, 2012d)*

The CEO then presented pathology staff within Organisation Y with a challenge. Although there was a clear requirement to make significant cost reduction savings, staff themselves were tasked with deciding the future of pathology services within Organisation Y. The CEO stated that if the 'enthusiasm and drive was there', which she believed was the case (personal notes) then staff could 'shape their own destiny' and reconfigure internally within Organisation Y (Organisation Y, 2012d).

If however staff felt that it was more appropriate to join the network, then she would honour that decision. In this case pathology management would put all of their 'energy into making the transition happen as smoothly as possible' (personal notes). The pace of change was highlighted during this discussion as staff were given just three months to review their current operations and feedback to the CEO directly.

During this intense meeting feedback from staff was limited to questions surrounding the timing of the proposal and the potential influence of the N.E.Path network especially with regard to the impact on staff. Although it was acknowledged that skill mix changes could lead to a potential reduction in the workforce the CEO viewed the internal configuration as the preferred option which would potentially have ‘less impact on staffing levels than that proposed within the network business case’ (Organisation Y, 2012e).

7.12.1 Staff reaction to collaborative approach

On the whole staff responded well to the request for a more collaborative approach. Not everyone was happy, however, and the response from union representatives although supportive raised a number of questions. Primarily these related to potential job losses as highlighted below (Organisation Y, 2012f):

> *‘staff are concerned that management’s focus is on cutting staff numbers, grades and salaries rather than introducing new business to offset the required cost reduction targets, and making the best use of staffs available skills’*

The union representatives also raised some interesting points with regard to the impact on service provision:

> *‘we strongly believe that we have an advantage over our competitors in the proposed network, due to us already having IT infrastructure, GP links and mirrored managed service contracts in place. We need to maximise the importance of this advantage and actively seek new businesses’.*

Within the context of this research the material affordance of a ‘mirrored managed service contract’ (Organisation Y, 2012f) refers to the provision of a dual tracking system on both urban sites.

Some clinical staff were also vocal in their objection to the process in particular a consultant microbiologist who was in favour of the network option. This consultant reiterated that ‘a failure to establish a hub lab will make our costs far too high in competition with other alternatives, including that of the private sector’ (Organisation Y, 2012g).

7.12.2 Staff mobilisation to rationalisation plans

Following the initial meeting I followed up the CEO presentation with another two open forum sessions with all staff invited to re-emphasise the aims of the project. During these conversations the staff and management group decided that the project would be divided between three working parties representing cellular pathology, microbiology and haematology/biochemistry combined. These individual groups all suggested their own approach to assessing the current and future state of the service. Staff from cellular pathology and microbiology opted for a lean methodology guided by work previously undertaken with the NHS Improvement team. During the course of two months, extensive process mapping was undertaken within microbiology and the group were obviously filled with energy and drive (personal notes).

Staff from haematology and biochemistry were much more reticent in their plans and a number of workshops were instigated to explore potential service models. During these workshops I presented staff with a sociomaterial review of pathology services. During these presentations I included slides produced by the primary supplier of the LSPA as part of their internal review. This included the capacity and demand models, which illustrated that from a technical perspective all of the cold work within Organisation Y could be undertaken on one of the two LSPA platforms within Organisation Y.

By the end of the first session the group debated the affordances and constraints of dividing the pathology workload between urban 1 and urban 2. It was concluded that rationalisation of services onto the urban 2 site would offer the potential to 'reduce duplicate kit' (LSPA) and offered significant opportunities to 'review skill mix' (Organisation Y, 2012h).

During this initial discussion some staff raised the issue of potential multi-disciplinary working as 'a rewarding experience' (Organisation Y, 2012h). Although this was an unexpected outcome, I felt that the option of multi-disciplinary working offered significant development opportunities for all grades of staff if it was undertaken in a collaborative manner. During a follow up meeting staff were more reticent, although full support was given for 'multi-disciplinary trained support staff' there was 'far less enthusiasm' within the biomedical scientist community (Organisation Y, 2012i).

7.13 Outcome of staff review in Organisation Y

During late October 2012 all three staff working groups presented their findings to an open forum, which included staff management and unions (Organisation Y, 2012j; 2012k; 2012l).

Within biochemistry and haematology it was agreed that the majority of staff supported full centralisation of cold work at urban 2 as an 'acceptable option' (Organisation Y, 2012l).

The principal concerns were documented as 'sample viability' 'transportation' and 'late production of results' (Organisation Y, 2012l). This last comment makes reference to the sociomaterial 'mangle in practice' (Pickering, 1995), which exists in the central reception area, especially evident when technological capacity does not meet demand as highlighted earlier in this chapter.

Within the biochemistry and haematology multi-disciplinary working was seen as 'desirable for support staff' but 'not feasible at this time for biomedical scientist staff due to reduced staff numbers and depth of knowledge required'.

However the concept of multi-disciplinary working was not ruled out entirely and it was suggested that this should be a ‘much longer term project’ (Organisation Y, 2012l).

During October 2012 N.E. Path released a highlight report (N.E.Path, 2012c), which stated that updates had been made to the N.E.Path OBC and the financial baseline data of Organisation Y had been removed (N.E.Path, 2012b). I can only presume from this document that internal conversations between the CEO of Organisation Y and the CEO of the N.E.Path network had taken place behind closed doors.

In November 2012 I produced a review of the internal reconfiguration plans for Organisation Y (Organisation Y, 2012m). This document (Organisation Y, 2012m) gave a clear message to the CEO that staff were supportive of the plans to rationalise services internally. The document went on to state that skill mix changes would be made in an ‘evolutionary manner’ (Organisation Y, 2012m). Although the appropriate cost savings were identified, these savings would only be realised over an extended time period. In the long term the proposed introduction of a multi-disciplinary working, at least for support staff would ensure staff development and improve service continuity.

During November 2012 it was formally acknowledged that the N.E.Path rationalisation model would not be progressed to full business case and hence the concept of a single managed Pathology network was at least for the time being put on hold.

7.14 Summary

This chapter has highlighted that the sociomaterial influence of LSPA appeared to be affecting organisational structures and working practices on both a micro and macro level. The affordances and constraints of LSPA observed on a micro scale within Organisation X also appeared to be having an effect within the reception area of Organisation Y. The embedded design features of a single automated tracking system, central loading point and integrated middleware required modifications to working practice. These modifications included the requirement to complete the specimen data entry process before specimen loading could be undertaken on the LSPA. The changes to practice were introduced by a combination of events. Firstly my own involvement in the project from a managerial perspective was highly influential as I transferred knowledge gained working with similar instrumentation in a different organisation, in this case Organisation X. Secondly changes to working practice were also significantly influenced by the primary supplier HCS management consultants. The HCS team brought knowledge and experience from a number of different sites together with a background of lean methodology. Both of these factors were seen to contribute to the development of similar working practice across the organisational boundaries.

Thirdly an understanding of the sociomaterial consequences of LSPA were relayed to staff within Organisation Y and appeared at least in part to influence the decision to rationalise pathology services internally rather than join the N.E. Pathology network. Thus a second ‘macro’ mangle in practice (Pickering, 1995) was created as documents and presentations from both Organisation Y and the N.E.Path network moved across organisational boundaries undergoing constant modification and revision between each social group.

Chapter 8 Discussion

8.0 Introduction

The aim of this research is to develop a theoretical model to explore how sociomaterial networks, involving large-scale automation, come into being, persist and change over time within a healthcare environment. In order to achieve this aim this research studies the on-going cycle of design, implementation and use of LSPA within two NHS pathology laboratories.

Since I began this research our understanding of the concept of sociomateriality has developed and alternative avenues have been explored with regard to the theoretical positioning. The term 'sociomaterial' has evolved into a heterogeneous body of work, based on multiple ontological perspectives, many of which do not appear to be mutually exclusive.

From a theoretical perspective, the 'morphogenetic' framework devised by Margaret Archer (1995), coupled with key tenets from ANT, will be utilised to develop a sociomaterial model, with which to assess the impact of LSPA within a pathology environment. During the course of this discussion, it will be argued that the development of this model overcomes some of the perceived limitations of other sociomaterial perspectives highlighted in the literature, such as a lack of attention to time and boarder social structures such as power (Faulkner and Runde, 2012; Mutch, 2013; Leonardi, 2013).

From a practical perspective the application of this model will highlight that collaboration and co-operation between both designers and users of technology can lead to technological innovation and improved organisational design.

8.1 Development of the sociomANTerial model

It is acknowledged by Mutch (1999, p.328) that the development of Archer's morphogenetic approach has resulted in a social theory that is 'complex, rich and difficult to simplify'. In accordance with Mutch (1999, p.398) what is presented below can only be considered to represent a brief sketch of the original concept, which it is hoped does not do 'too much violence' to the original theory. At the risk of generating yet more 'jargon monoxide' (Sutton, 2010) I have introduced the term sociomANTeriality from a theoretical and practical perspective. The concept of social realism does not explicitly address the influence of technology and hence the introduction of key tenets from ANT makes a significant contribution to the development of a sociomaterial model based on the morphogenetic approach. Secondly it has been acknowledged during the literature review that the term sociomateriality is based on a number of diverse theoretical footings and hence the use of the term sociomANTeriality distinguishes this approach from other conceptualisations.

8.1.1 The Morphogenetic approach

The 'morphogenetic approach' has been advanced by Archer (1995, p.192) as a means of operationalising the analytical dualism between structure and agency and hence bridging the gap between the two. Accordingly, the human and social elements of everyday life are considered to be ontologically distinct but none the less intimately interlinked as they emerge from different strata as highlighted by Archer (1995, p.166) below:

> *'because the social world is made up, 'inter alia', of structures and of agents and because these belong to different strata, there is no question of reducing one to the other or of eliding the two and there is every reason for exploring the interplay between the world' (Archer, 1995, p.62).*

In essence the central argument of the morphogenetic approach is that the structure and agency can only be linked by the interplay between the two over time.

8.1.2 Emergence and stratification

The development of a sociomANTerial model, based on the morphogenetic approach, therefore acknowledges that we are concerned with three kinds of stratified and emergent cycles, encompassing structure, culture and human agency (people). The morphogenetic approach is envisaged as overcoming the traditional structure/agency debate such as that posed within Giddens (1984) structuration theory, by considering these individual cycles to operate with relative autonomy and yet being capable of interacting with one another.

Within the morphogenetic approach, society is considered to be an open system because it is 'peopled', and being 'peopled', it can always be 'reshaped through human innovativeness' (Archer, 1995, p.166). The world is then conceptualised as being made up of layers, emerging from each other but not reducible to it. Within this context it is important to recognise the tripartite division into persons, agents and actors. Persons are then considered to be emergent as individuals but not reducible to their biological make-up. As agents, they are defined by roles and positions capable of making passive or active roles within an organisation. The concept of emergence and stratification allows an appreciation of the influence of actors emerging as powerful individuals or groups. As actors emerging from the collective agents, they are 'enabled or constrained by the characteristics of both groups and of the structured situation they find themselves' (Mutch, 1999, p.328). Importantly within the context of this research an appreciation of both managerial or 'corporate agents' and 'primary agents' (Horrocks, 2009, p.41) in the form of users of LSPA technology (biomedical scientists/support workers) are considered particularly valuable. Primary agents are therefore considered to be distinguished from corporate agents because the former ‘lack a say in structural and cultural modelling’. In doing so they are considered to ‘neither express interest in, nor organise their strategic pursuit’ (Horrocks, 2009, p.41). Within a pathology environment however collaborative working practices and user involvement in the change process, facilitated the transition of primary agents into corporate agents, a factor that will be explored in greater detail during the later stages of this discussion.

Analysis of the morphogenetic cycle is then considered to ‘set out the conditions under which change or reproduction is likely to occur in social, structural, and cultural contexts and to produce an analytical history of this without having to resort to a determinist approach’ (Horrocks, 2009, p.40). Of particular importance is the proposition that when the morphogenetic/static cycles of structure and culture are synchronised then there are ‘reciprocal influences’ between them. Conversely when the cycles out of sync ‘one will be more consequential for the other, temporally and temporarily’ (Archer, 1995, p.308). In other words change or morphogenesis occurring within the structural cycle, accompanied by ‘morphostasis’ (Archer, 1995) in the cultural cycle will be short lived and unsustainable.

8.1.3 Maintaining the ontological divide

Within the development of the sociomANTerial model the emerging cycles of structure, culture and people are conceptualised as being ontologically distinct, yet intimately linked, via ‘interplay’ over time.

This focal concern with ‘interplay’ is considered by Archer (1995, p.15) to distinguish the morphogenetic approach from other social theories ‘whose preoccupation is with interpenetration’, such as the ‘agential realist’ perspective developed by Barad (2003).

Treating all relationships as interpenetrative or mutually constitutive (Orlikowski and Scott, 2008a; 2008b) however causes significant theoretical issues for a research design based on bridging the gap between the design and use of relatively fixed function technology such as LSPA. The transition from design intention, implementation and subsequent use in practice requires that we conceptualise the material and the social as distinct entities. Bridging the gap between design and use would by definition appear to be at odds with the ‘agential realist’ approach, which replaces the idea of materiality as ‘preformed substances’ with that of ‘performed relations’ (Orlikowski, 2007, p.1437).

A related criticism of the agential realist perspective revolves around the perceived strength of the relationship between the material and the social. The agential realist perspective of ontological inseparability poses significant problems for scholars wishing to undertake empirical study as highlighted by Faulkner and Runde (2012, p.58) below:

> *‘if the contents of the world are not separated by intrinsic boundaries as Orlikowski and Scott (2008b) would have it, on what basis do we distinguish between things, be this in our capacity as researchers or simply as people going about our everyday affairs?’*

While it is acknowledged by Faulkner and Runde (2012) that the concept of ‘interpenetration’ may be intended metaphorically along the lines of Harraway’s (1991) ‘cyborg manifesto’ they ultimately reject the concept on both empirical and operational grounds. Within a health care environment, it is unclear for example how ‘wooden boxes’ and ‘A&E consultants’ (Crump and Latham, 2012, p.61) could be considered ontologically inseparable. Likewise in the context of this research there would appear to be difficulty conceptualising the ‘interpenetration’ of laboratory staff and relatively fixed function technology such as LSPA.

Leonardi (2013) takes this argument one stage further suggesting that from an agential realist perspective ‘actors in the world’ or ‘normal human beings’ (Sutton, 2010) do not conceptualise the human and the social as being interpenetrated entities. This issue has obvious empirical implications for researchers adopting an ethnographic approach, which strives to understand the world as perceived by the human at the centre of the research. For example, the study design devised to understand both the perceptions of designers and managers, which formed the basis of the semi-structured questions used as part of this research immediately, introduced a divide between the material and the social.

As highlighted by Kautz and Jensen (2013, p.24) the adoption of the agential realist perspective may be partly explained by the environment in which the research takes place. While the adoption of the agential realist approach may be applicable to ‘fleeting’ or ‘ephemeral technologies’ (Law and Urry, 2004, p.403) such as the Google search engine (Orlikowski, 2007) or ‘TripAdvisor’ (Orlikowski and Scott, 2012), it may be less appropriate to examine the effects of more fixed form technologies such as LSPA.

In contrast to those authors who suggest that the social and material are ‘mutually constitutive’, (Orlikowski and Scott, 2008a; 2008b), other researchers such as Pickering (1995) and Leonardi (2011) have developed sociomaterial theories, which maintain the ontological divide, whilst still acknowledging a mutual entanglement. In order to unravel the relationship between the material and social agency both the 'mangle of practice' (Pickering, 1995) and 'imbrication' (Leonardi, 2011) metaphor utilise the concept of material affordances and constraints to conceptualise the temporal nature of change in both the human and material elements. Changes to 'organisational routines' or 'material forms' are considered to provide a means of observing how the interaction of human and material agency affects organisational development over time.

With regard to this research however an appreciation of change to organisational routines or material forms 'in practice', would appear to be one-dimensional and underplay the role of broader social structures such as power. As such, both the 'mangle' (Pickering, 1995) and 'imbrication' (Leonardi, 2011) metaphors in isolation fail to provide the ontological depth developed within the sociomANTerial model to conceptualise the transition from design to use and the influence of external pressures such as the UK government's drive to modernise pathology services. The 'perception' of technologies affordances and constraints in isolation is also considered to fall short of a detailed analysis of why and how a technology comes to be considered a candidate for selection in the first place. During the development of the sociomANTerial model the inclusion of a theory of temporality within the morphogenetic framework will be considered to overcome these perceived limitations and is described in more detail below.

8.1.4 Inclusion of a Theory of temporality

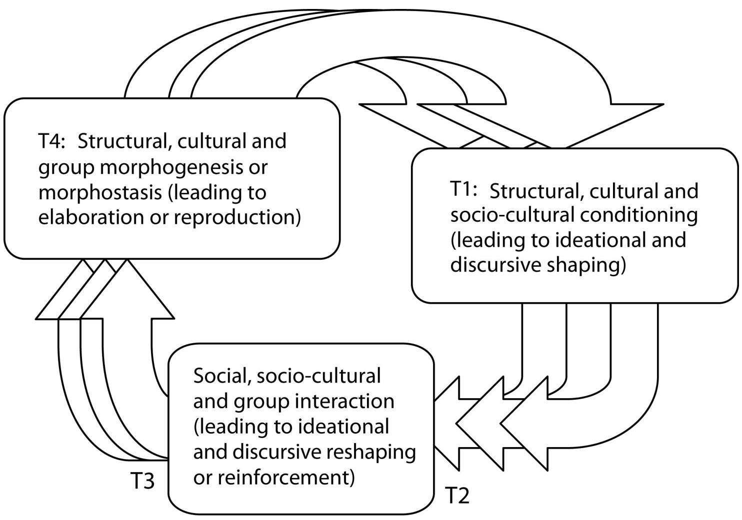
Within the literature review it was acknowledged that the sociomaterial model based on the 'agential realist' approach proposed by Barad (2003) failed to appreciate the influence of time. The transition from 'interaction', which presumes a prior existence to 'intra-action', is considered by Barad (2003) to be a profound conceptual shift. Accepting an ontological perspective however which denies any prior existence, fails to identify the historical context or conditions with which such practices were established. According to Leonardi (2013, p.67) a failure to appreciate time makes it impossible to explain why practices 'arise, endure or change'. Within the context of this research, adopting an agential realist perspective would deny the preconceived development of technology and the subsequent influence on working practices. Utilising the agential realist perspective in the form perceived by Orlikowski and Scott (2008a; 2012) makes it difficult to understand how the intentions of designers are subsequently embedded into technology and how those intentions are subsequently realised or not in practice. As such it is argued that the sociomaterial framework based on the agential realist perspective provides an inadequate theoretical model with which to explore the impact of fixed function LSPA technology across time, space and organisational boundaries.

Within the sociomANTerial model these criticisms are overcome by considering the influence of time from two dimensions. Firstly according to Volkoff, Strong and Elmes (2007, p.835) the social realist theory of Archer (1995) involves three phases which can be utilised to assess the impact of technology mediated organisational change as follows:

- Structural conditioning, the pre-existing structural properties that are the consequence of past actions, followed by,
- Social interaction, during which agents engaged with, and are constrained and enabled by, the pre-existing structural conditions, followed by,
- Structural elaboration/reproduction, the modification of previous structural properties and the introduction of new ones or the reinforcing of existing structures.

According to Porpora (2013, p.28) the morphogenetic approach signifies that 'people always act out of structural and cultural circumstances, which vary their actions then proceed to modify or sustain'. Within the morphogenetic cycles the element of time (T) is introduced and diagrammatically illustrated below:

Figure 13 The morphogenetic cycle (Horrocks, 2009, p. 40)



Mutch (1999, p.330) argues that analysis of any social interaction should begin at Time 1 (T1), that is when the structural conditioning takes place, which form the context for the interaction rather than at Time (T2), which is when the interaction actually takes place.

From an empirical standpoint within the development of the SociomANTerial model the identification of T1 will be a matter of choice. The important consideration is that social conditioning allows the researcher to consider the ‘antecedent circumstances’ (Porpora, 2013, p.28) of previous social elaborations and hence allows a consideration of broader social influences such as institutions, organisations, markets, or sets of ideas’ (Mutch, 2002, p.487). According to Horrocks (2009, p.43) the so called ‘first order emergents’ produced a result of social conditioning include the ‘structures, systems, roles/positions and bargaining powers of agents’. During the course of this research within Organisation X and Organisation Y, first order emergents were largely created by the generative powers of the UK government’s pathology modernisation agenda. Within both organisations social conditioning was influenced by the threat of regional rationalisation of service. As a response to this threat both organisations responded by purchasing LSPA as a ‘defence against pathology modernisation’ (Section 6.6.5; 7.9). The impact of LSPA on within both organisations was envisaged as influencing structures, systems and the roles of individuals by facilitating the introduction of multi-disciplinary working (section 6.6.5; 7.4).

With regard to social conditioning however a number of factors are considered to come into play, not least that people have ‘reflexive powers’ which means that conditioning is not ‘a law or a force’ but a ‘reason’ in which humans enjoy interpretive flexibility (Horrocks, 2009, p.41). As people act within their structural and cultural circumstances during the social interaction phase, T2, ‘second order emergents’ (Horrocks, 2009, p.41) are experienced as ‘operational obstructions’ and ‘practical problems’, affording or constraining human agency as highlighted below:

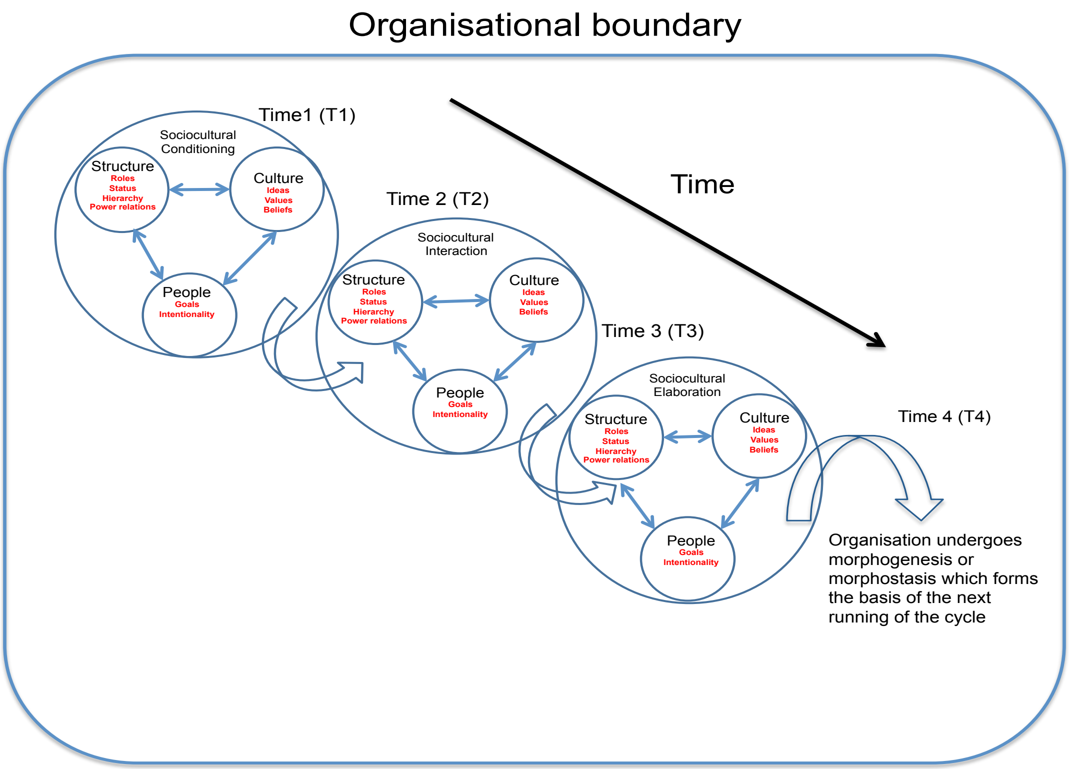
> ‘focusing on second-order emergents therefore provides us with ‘the bridge between real but unobservable systemic properties (complementarities and incompatibilities) and their impact upon daily experience at the level of events’.

As a result of this social interaction at time 3 (T3) people either maintain or reproduce these structural and cultural conditions in a process Archer (1995, p.199) terms structural, cultural or group ‘elaboration’. The role of the social scientist is then to discern the cultural and structural conditions under which social interaction takes place.

The cycle is then completed by an assessment of the structural elaborations either (socio-cultural morphogenesis or morphostasis), which take place and form part of the structural conditioning in the next running of the cycle at time 4 (T4).

The introduction of a theory of temporality within the sociomANTerial model therefore allows the researcher to trace an analytical history of organisational change, including the impact of broader social structures such as power and the influence of cultural factors over time. The interplay between structure, culture and people are observed within each phase of the cycle. Within the sociomANTerial model this change process is considered to take place within the confines of an organisational boundary, illustrated by the encompassing blue line within figure 14 below:

Figure 14 The influence of time operating within a single organisation



Secondly within the context of this research the development of the sociomANTerial model allows us to consider that an artefact's material properties pre-date action and the perceptions it will help create. In essence, users are introduced to a technology whose materiality has already been pre-configured for them.

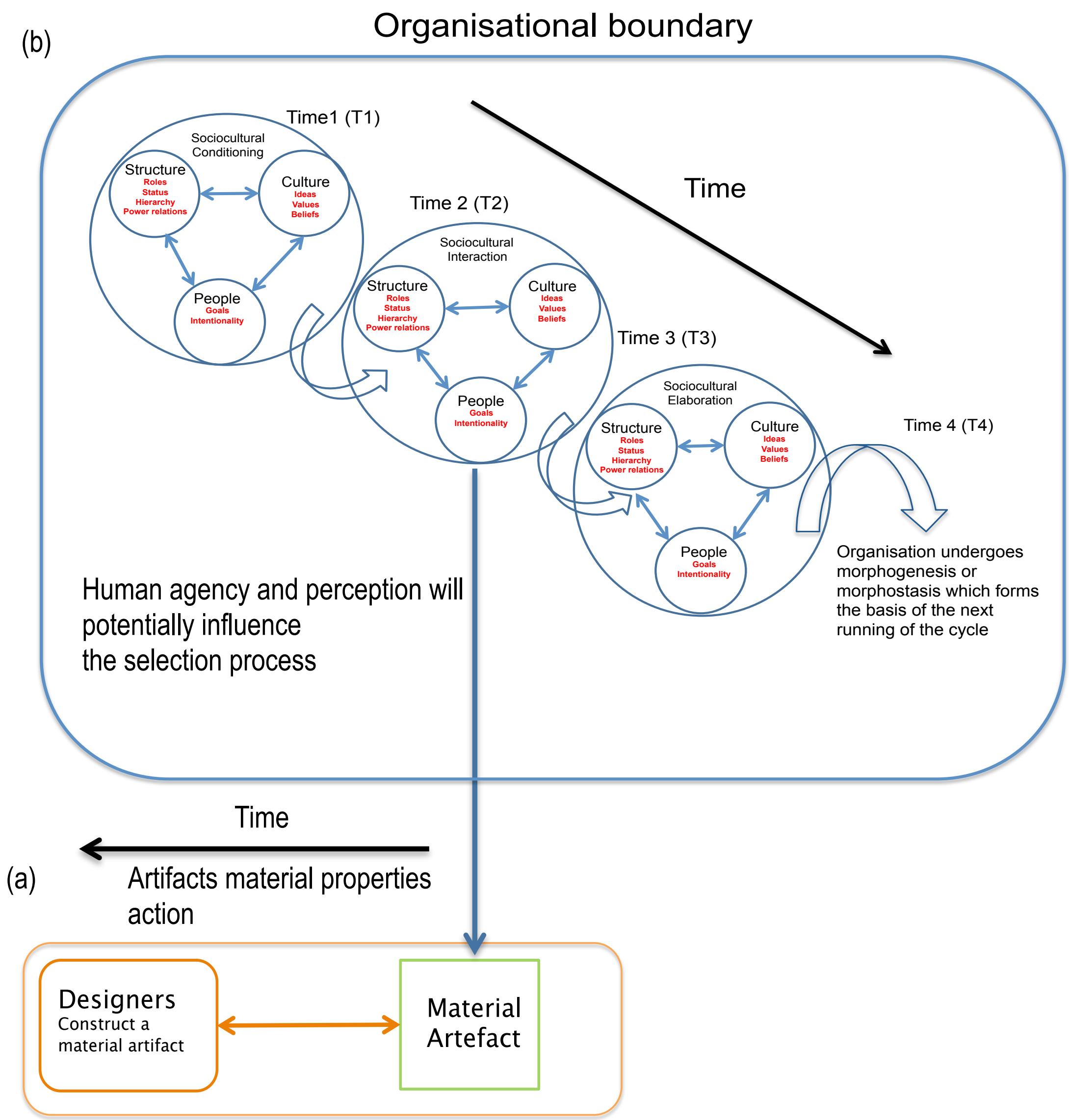
According to Leonardi and Barley (2008, p.166) with a few notable exceptions, (Orlikowski, 1996; Thomas, 1994; Leonardi, 2007) research into the effects of technology on organisations and users has traditionally focused on what happens before, or after, technology is introduced into a work setting. In essence the design cycle has always been investigated internally within a single organisation. As a result, designers and the users of technology have worked collaboratively together and hence the time-line for such investigations has been relatively short. This factor is considered by Leonardi and Barley

(2008) to offer obvious empirical advantages within a research timeframe. Within this context the design cycle could effectively be considered to occur 'in action' and hence the use of the 'mangle of practice' (Pickering, 1995) or 'imbrication' (Leonardi, 2011) metaphor would appear to be a more appropriate analogy.

Uniquely, within the context of this research however, the designers and users of LSPA technology are separated by time, space and organisational boundaries. A significant theoretical advantage of sociomANTerial model over other sociomaterial frameworks is the acknowledgement that the design phase can exist externally to the user organisation and hence occurs antecedent to the subsequent introduction of the technology. As a result of these factors the development of the sociomANTerial model acknowledges that the perceptions of an artefacts materiality can also predate its introduction into the workplace. According to Leonardi (2013, p.69) the perceptions of a technologies affordances and constraints are 'constricted to a large degree, by the initial materiality that they encounter when first using the technology'.

This research highlighted that pathology managers within the North East of England approached LSPA technology with a number of diverse goals and perceptions of the technology prior to selection (section 6.1 & 6.2). It will be argued during the course of this discussion that in addition to the perceptions afforded by a user's first encounter with a technology, the selection process itself (section, 6.3) illustrated by the blue line between user and designers in figure 15 below can also provide a wealth of rich information about the 'dynamic and interactive nature of the relationship between the technical and social systems' (Thomas, 1994, p.4).

Figure 15 Impact of time within the sociomANTerial model



Key **(a)** **Technology designer organisation**

(b) **Technology user organisation**

8.1.5 Influence of technology

The social realist perspective utilised by Archer (1995) within the morphogenetic approach does not formally acknowledge the role of technology in the change process. In order to overcome this inherent limitation, Mutch (2002; 2010; 2013) suggests that ideas drawn from ANT may provide a useful addition to the framework. In particular, it is argued that the place of technology in both social interactions and structural conditioning is an 'invisible one at present', as such ANT offers a means to 'render technology visible' (Mutch, 2002, p.488). It is acknowledged by Mutch (2002, p.490) that the durability of a network involves the 'inscription into material form of the assumptions that underpin the interests of particular actors in a network'. The degree of inscription is seen to afford and constrain action, the degree to which depends on the irreversibility of such inscriptions, and the unravelling of the enrolments that happen to construct such inscriptions' (Mutch, 2002, p.490).

The emphasis on technology is then considered by Mutch (2002) to fit well with the social realist concept of emergent properties. In particular, technology is considered to 'inscribe structural elaboration into relatively fixed properties that then form the social conditioning of the next round of social interaction' (Mutch, 2002, p.491). Mutch (2010, p.511) argues that researcher's need to consider 'which structures are embedded in technology' and at 'which level and also how such embedding is perceived by and responded to by a range of users'. Technology is therefore not considered a 'structure in its own right but one of the ways structure is mediated'.

According to Papadopoulos, Radnor and Merali (2011, p. 172) the concept of 'inscription', involves the 'creation of an artefact to ensure the interests of the actor-network, in this case that of the suppliers of LSPA are protected. A material artefact is thus inscribed with structural meaning, which will be transferred from the designer to the user.

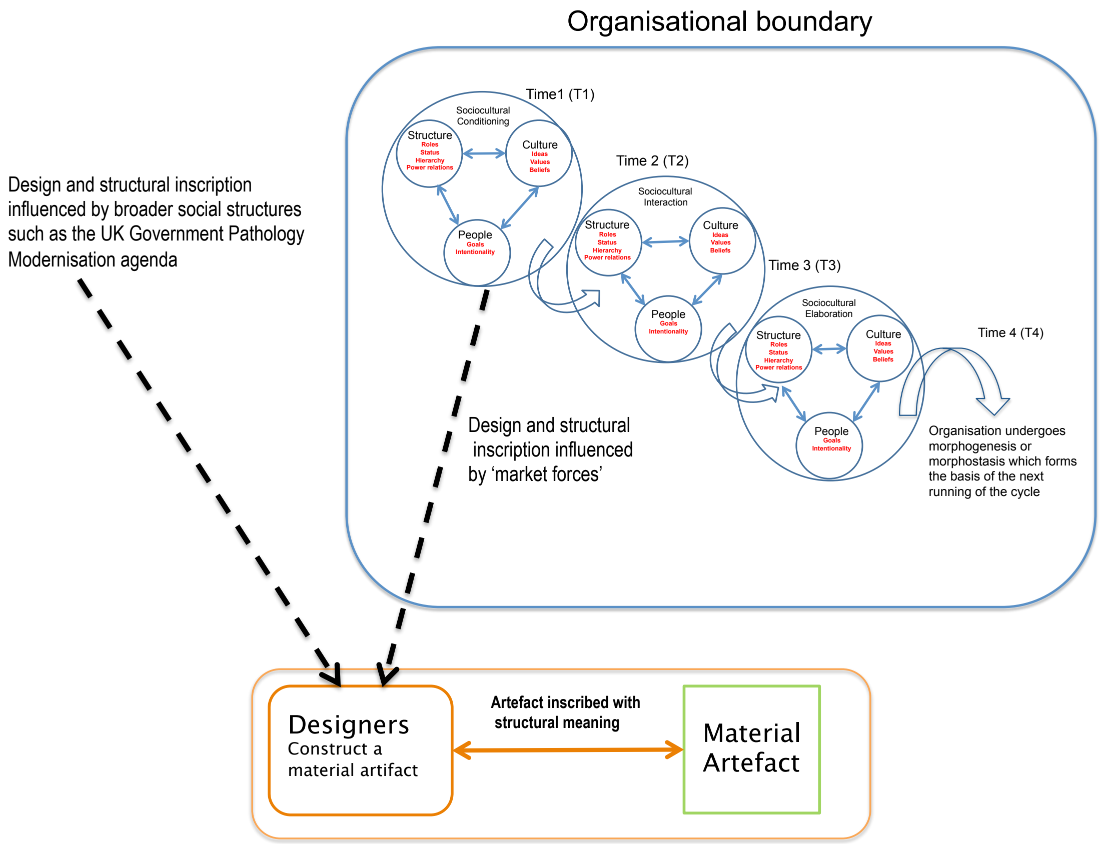
A fundamental aim of this research was to investigate if designers of LSPA purposefully intended to modify the working practices and organisational structures of user organisations. As can be seen from the results section (5.4.2 & 5.4.4), this was indeed the case and a number of design features have been identified as embedded within the material properties, to facilitate these changes. Within the sociomANTerial model the inclusion of the concept of inscription, developed from ANT, together with the theoretical underpinning of social realism, allows us to clearly define how designers of LSPA technology embed their structural intentions into the material fabric of the automation. It is suggested here that the identification of the inscribed features within a material artefact allows us to gain a better understanding of the design intentions of suppliers, and conversely a better understanding of what designers are trying to do to themselves.

Within the context of this research the social conditioning, taking place within the supplier organisation at the design phase did not occur in isolation. According to members of the HCS team the design of LSPA technology appeared to be driven by the ‘market’ (Section 5.4.4). It was acknowledged that the supplier organisation was responding to the demands of user organisations and reacting to the constraints produced as a result of an aging biomedical scientist workforce and failure to train or recruit adequate numbers of qualified scientific staff (section 5.4.1). Representatives from the supplier organisation acknowledged that pathology laboratory managers both within the UK and the USA considered that a reduction in scientific grades of staff would be compensated by an increase in automation (section 5.4.1). The increase and associated ease of use of this technology could be operated by less academically qualified support grades of staff and hence skill mix changes and financial savings would be released as a result.

Within the UK market it was acknowledged by members of the HCS team that the design of LSPA was influenced by the pathology modernisation agenda (section 5.4.1). In particular the design of LSPA technology embedded a worldview of laboratories wishing to integrate, consolidate and form networks. Hence external market forces and broader social structures such as the power of the UK government to drive rationalisation of pathology services by the formation of formally managed networks, in part influenced the design of LSPA technology.

Figure 16 below highlights that a material artefact inscribed with structural meaning is created prior to the introduction within a user organisation. In addition the diagram highlights the impact of internal ‘market forces’ such as the requirement to compensate for an aging biomedical scientist workforce together with the impact of external broader social factors such as the UK government pathology modernisation agenda.

Figure 16 Influence of broad social structures and market forces on the design and structural inscription of a material artefact



In order to highlight the influence of these broader social structures, the application of ANT within the sociomANTerial model is extended to provide a means of exploring and tracing the 'ties in networks' (Orlikowski and Scott, 2008a p.25). During the course of this research the material effects of LPSA technology appeared to operate on two different levels. Firstly, the material affordances and constraints appeared to have their effect 'in practice' on a 'micro' scale within the reception areas of both Organisation X and Organisation Y. Secondly, within Organisation Y these material affordances and constraints were considered to have an effect on a 'macro' scale influencing the decision making process whether to centralise pathology services regionally as part of the modernisation agenda, or to rationalise internally. As such, the materiality of the LSPA technology was subsequently inscribed within internal documents, which subsequently acted as ‘boundary objects’ (Star and Griesemer, 1989; Carlile, 2002; 2004) passing back and forth between laboratory staff and senior management.

During the course of this discussion the key tenets of ANT will therefore be utilised to explore the complex network of activities, which emerged during the transformation of pathology services within Organisation Y during the third morphogenetic cycle identified later in this discussion.

8.1.6 Generative mechanisms

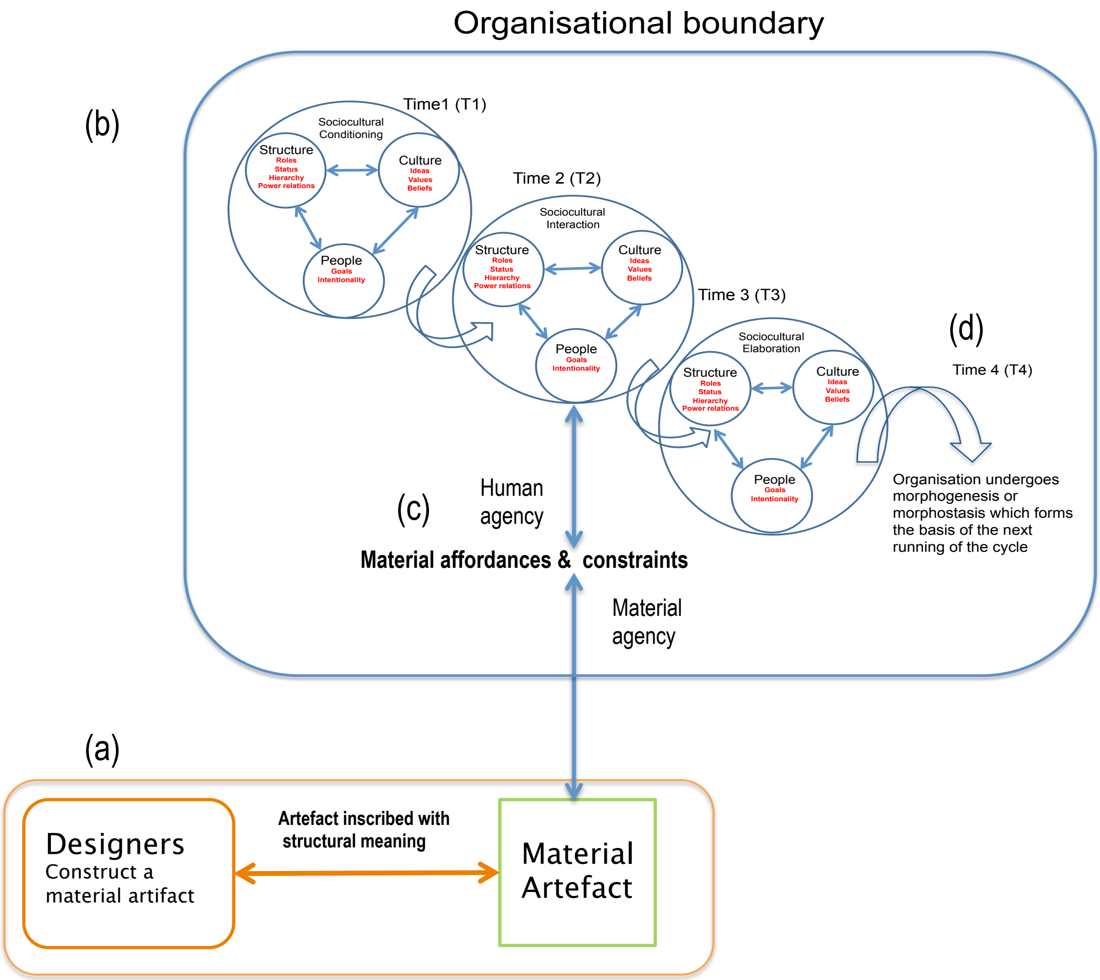
According to Mutch, (1999, p.329) a fundamental element of the social realist perspective is its emphasis on and search for ‘generative mechanisms’, which might operate at a deeper level than the ‘constant conjunctures’ often mistaken by positivists for ‘cause and effect’.

In order to conceptualise how the material and social are brought together and hence elucidate ‘generative mechanisms’ Leonardi (2013) suggests that a social realist approach would benefit from adopting the ‘imbrication’ metaphor as a means of creating the “sociomaterial”. The concept of human and material elements ‘imbricating’ or ‘interlocking’ would however appear to be a significantly stronger relationship than that proposed by the ‘interplay’ analogy suggested by Archer (1995, p.15). In order to remain faithful to the social realist philosophy the sociomANTerial model utilises the concept of material affordances and constraints in order to elucidate the nature of deeper generative mechanisms operating between the social and material elements.

According to (Horrocks, 2009, p.43) social interaction is accompanied by the production of second order emergents, which are experienced as 'operational obstructions' and 'practical problems' affording or constraining human agency. Focusing on second-order emergents is considered by Horrocks (2009, p.43) to provide a bridge between 'real but unobservable systemic properties (complementarities and incompatibilities) and their impact upon daily experience at the level of events'. With regard to this research second order emergents were experienced as over and under production in the central reception areas of both Organisation X and Y, which resulted in increased pathology result turnaround time. In addition misaligned and poor quality barcodes produced via the order communication route required staff in the central reception area to manually re-label 30% of specimens, which introduced a significant clinical risk to the process. An appreciation of the sociomaterial influence of LSPA on organisational structures and routines together with the affordances and constraints of the technology allowed 'unobservable systemic properties' (Horrocks, 2009, p.43) to be made visible. Operational problems resulting in increased result turnaround time, and an inability to process poor quality mis-aligned barcodes could be traced to design features built into LSPA technology. These features included the single automated tracking system, central loading point for specimens and integrated middleware, which required modification to organisational routines. The failure of staff to maintain and sustain these changes to routine compounded the operational difficulties and exacerbated the problems. In essence focusing on the sociomaterial affordances and constraints of LSPA technology allowed the elucidation of deep generative mechanisms rather than focus on second order emergents. The elucidation of deep generative mechanisms would then appear to advance our understanding of the morphogenetic approach from both a theoretical and practical perspective.

The resulting model of sociomANTeriality based on the underpinning philosophy of social realism and the 'morphogenetic' approach of Archer (1995) coupled to key tenets of ANT is highlighted in figure 17 below:

Figure 17. The SociomANTerial model



Key

(a) Designers of technology separated in space and time from user organisation inscribe a material artefact with a world view
(b) Technology impacts on user organisation and results in a social interaction
(c) Material agency affords or constrains human action, requiring changes to organisational routines or changes to technology
(d) Sociomaterial interaction impacts on organisational structures, cultures and people leading to morphogenesis and or morphostasis which in turn forms the next round of sociocultural conditioning

The remainder of this chapter will assess the practical consequences of adopting the sociomANTerial model in practice within two different NHS pathology laboratories. This section is divided into three interlinked and evolving morphogenetic cycles. Social interaction within the first cycle is observed to originate following the introduction of LSPA technology within Organisation X. The material affordances and constraints of LSPA technology are observed to create operational difficulties requiring modification to organisational routines and structures. During the course of this research these changes to structure and routine are transferred to Organisation Y via my appointment as Lead Biomedical Scientist in Haematology. As a result of this transfer the 'mangle of practice' (Pickering, 1995) observed to be created within the central reception area within Organisation X was recreated within Organisation Y. Following this managerial transfer and sociomaterial interaction a second morphogenetic cycle was observed to take place following social interaction orchestrated by the author as researcher/manager and the primary supplier HCS team. This social interaction included a wide-scale review of service together with recommendations for structural change. The third running of the cycle centred on user and corporate involvement within the change process, including the fundamental strategic decision to engage with regional pathology modernisation agenda or rationalise services internally.

8.2 Practical application of the SociomANTerial model of pathology services

According to Mutch (2010, p.511) when considering the relationship between structure and agency, a useful starting point is to draw the distinction between the primary and secondary phase. Within the primary phase, designers are perceived as inscribing 'abstract features from the world in order to construct a technological artefact that is presented back as if it were neutral'. The artefact is then ‘appropriated in the secondary phase, in which users creatively receive it’. Within the context of this research, the primary phase of the sociomaterial relationship was investigated by assessing the design intentions of suppliers of LSPA technology. An assessment will then be made of how these design intentions subsequently became inscribed within the material properties of the technology.

8.2.1 Primary phase analysis - Bridging the gap between design and use

During the course of this research my collaborative long-term relationship with the designers of LSPA has allowed me access to members of the design team capable of answering the following secondary research questions:

- Do the developers of LSPA purposefully intend their technologies to shape the work practices of users or the structure of organisations?
- If so how do designers of LSPA technology embody their intentions in designs?

The following section of this chapter will highlight that developers of LSPA technology do indeed intend to influence working practices and staffing structures within organisations. Three specific design features will be highlighted which embody these design intentions in material form.

8.2.2 Do the developers of LSPA purposefully intend their technologies to shape the work practices of users or the structure of organisations?

Template analysis highlighted that all five representatives from the primary supplier organisation stated that the introduction of LSPA was designed to change working practice within a laboratory environment (Appendix 6). Four out of the five respondents stated that the primary design intention was to facilitate ‘multi-disciplinary working’ primarily as a function of the simplicity of the technology. Within this context multi-disciplinary working was considered to take both a social and material form. From a social perspective ‘multi-disciplinary’ working refers to the ability of laboratory staff to have the knowledge and skills to operate in multiple pathology disciplines, for example biochemistry and haematology. From a material perspective, the introduction of LSPA was seen as a means of bringing together physically disparate disciplines onto a single automated platform.

Multi-disciplinary working was considered a means of overcoming the cultural barriers within a pathology environment identified during the course of this research by both primary supplier representatives (section, 5.5.2) and pathology managers (section 6.1.7).

All five managers from the supplier organisation stated that the introduction of LSPA would be expected to bring about changes to the staffing structure of user organisations, either by a reduction in head count of the biomedical scientist workforce or by altering the ‘skill mix’, to facilitate increased use of laboratory support staff.

The primary supplier of the LSPA has during the course of this research been very open about their intentions to change staffing structures. In the words of the HCS team member they are ‘constantly requested’ to make suggested changes from ‘the market’ (S2) (section 5.4.4).

The ability of LSPA management consultants to influence working practices and staffing structures is to a large extent dependent on the contractual arrangements included within the MSP. The MSP defines a long-term relationship between the designer and the user of LSPA and is considered to be novel within a healthcare environment. This relationship extends to maintenance, training and on-going service design through both the implementation and the HCS team. In essence it makes financial sense for the supplier to collaborate with the user to optimise organisational performance in order to maximise profit. Although this relationship could be considered to be little more than privatisation thorough the back door, the constant attention from the supplier offers significant affordances with regard to 'fixed form technology' such as LSPA.

Within an IS environment, research Orlikowski (1996, p.90) acknowledges that technologies' materiality allows for 'easy on-going changes'. Indeed customisation is often required for 'effective operation' and 'on-going learning in use'. As a consequence technological and organisational changes are encouraged. This is in direct contrast to more 'fixed-function technologies', which are considered 'difficult and costly, if not impossible to change' (Orlikowski, 1996, p.90; Leonardi and Barley, 2008, p.171).

The procurement of LSPA via an MSP therefore makes it possible to make changes to relatively 'fixed function' technology (Orlikowski, 1996, p.90), which would otherwise have been difficult and costly to achieve. This point is illustrated within Organisation Y, where following implementation and use of the LSPA, proposed changes in organisational structure were modelled on modifications to the LSPA technological platforms. The ability to even consider these 'revised modelling vectors' (Pickering, 1995) is premised on the fact that the primary supplier, not Organisation Y, owns the technology. The collaborative relationship with the primary supplier, granted Organisation Y management consultants and technical staff the ability to realise these changes in practice, at relatively little cost to the user. It is in the best interests of both organisations to 'facilitate cooperation over time, space, boundaries and cultures' (Berg, 1999a, p.374).

8.2.3 How do designers embody their intentions in designs?

This research highlighted three key features, which embodied the primary supplier design intention to facilitate multi-disciplinary working. These features included the introduction of a single pathology platform (Design feature 1), a central loading point for specimens (Design feature 2) and a system of integrated middleware (Design feature 3) to control the entire platform from a single point of access.

The single automated platform (Design feature 1) was seen as a means of bringing together pathology analysers from a range of different disciplines e.g. haematology and biochemistry into the same physical space. In addition the single automated platform contained a number of dedicated instruments designed to automate the pre-analytical stage of the process. The materiality of the track was then designed to constrain human agency, which would in theory be reduced to loading and unloading large racks of specimens via a central loading point (Design feature 2). Automating almost the entire pre-analytical pathology process was then seen as a means of creating a manufacturing style production system, which could potentially be operated by relatively unskilled support workers.

The opinion that non-scientifically trained support staff could use this automated system is reminiscent of the technological threat from pathology automation observed three decades ago by Pasmore, Petee and Bastian (1986, p.330):

> *'Within the Biochemistry department many staff were of the opinion that the introduction of technology had simplified the job to the point that 'technically trained high school students could perform it'.*

8.2.4 Selection process

According to Thomas (1994), the selection process itself provides a wealth of information on the decision to adopt a particular technology and is seen to be a significant bridge between design and use. During the course of this research, the influence of site visits, are seen to significantly influence the decision making process.

Developing an understanding of the 'alternatives considered but not selected', is also deemed to be important because these alternatives 'violate existing assumptions about the "proper way" to structure work' (Thomas, 1994, p.12). Within the context of this research the "proper way" to structure work' (Thomas, 1994, p.12) would include maintaining or discouraging the deep-rooted cultural divides identified previously within pathology (Pasmore, Petee and Bastian, 1986; Valentine and Behara, 2001; Wainwright and Shaw, 2007; 2008; 2013).

Directly or indirectly, the embedded design features of the LPSA technology identified above would appear to embody the social and political 'vision' of the UK government in material form with regard to the pathology modernisation agenda. The introduction of LPSA technology is perceived to simplify and automate previously manual processes; overcoming cultural boundaries and facilitating skill mix changes in order to reduce costs and encourage the development of formal pathology networks.

Table 23 contrasts the aims of the UK government with regard to pathology modernisation, the design intentions of the primary supplier of LSPA together with the views of the majority of pathology managers within the N.E. of England.

Table 23. Contrasting 'visions' of the UK government, designers and users of LSPA

UK Government modernisation agenda	**Design intentions of primary supplier of LSPA**	**Aims of pathology managers within the N.E. of England**
Increase use of technology	Increase use of technology	Increase use of technology
Automate processes	Automate processes	Automate processes
Consolidation of services (formally managed networks	Consolidation of services (formally managed networks	**Internally re-configure services**
Reduce cost	Increase profit	Reduce cost
Increased use of support staff	Increased use of support staff	Increased use of support staff
Decrease number of scientific BMS staff	Decrease number of scientific BMS staff	Decrease number of scientific BMS staff
Reduce cultural divide	Reduce cultural divide	**Overall maintain cultural divide**
Utilise lean principles	Utilise lean principles	Utilise lean principles

According to the designers of LSPA, only 15-20% of users worldwide have purchased the entire single-track option from the primary supplier. This single-track option incorporates both haematology and biochemistry and within the context of this research is seen as a fundamental design feature, to facilitate the design intention of multi-disciplinary working. Following a number of interviews undertaken with pathology managers as part of this research the figure of 15-20% of potential users considering the selection of a single track LSPA was further confirmed. It can then be inferred that 80% of users have opted for the dual track option, which maintains at least the physical if not the cultural divide between the departments.

The perceptions of the majority of pathology managers would appear to differ from those of the primary LSPA supplier and also the UK government in two important aspects.

Firstly the majority of pathology managers within the N.E England, including those within Organisation Y, were content to maintain the traditional cultural divide, which exists between departments indicated by the selection of dual LSPA system. The selection of LSPA therefore would appear to involve 'normative pressures' which stem predominantly from 'professionalisation' or the drive for the legitimation of 'professional autonomy' (DiMaggio and Powell, 1983, p.152).

Secondly, six of the ten pathology managers, interviewed as part of this research were adopting LSPA to facilitate 'inter-laboratory centralisation', rather than regional consolidation within the modernisation agenda and hence conceptualised the technology primarily as a socio-political tool, rather than an analytical instrument.

8.3 Do such design intentions subsequently have their effect in practice? If so why? if not, why not?

A significant advantage of the social realist perspective, based on emergence and stratification, over the agential realist perspective, is the ability to reflect on the structural, cultural and position practices, prior to any technological interaction. Mutch (1999, p.330) argues that analysis of any social interaction should begin at T1, which is when structural conditioning takes place, in order to form the context for the interaction. From a practical perspective, an assessment of social conditioning, allows scholars to consider the broader social structures influencing the perceptions of corporate agents involved in the selection process. The next section of this chapter will then highlight the socio-cultural conditioning influencing Organisation X and Y as a result of the UK government drive to modernise pathology services.

8.3.1 Cycle 1 Socio-cultural conditioning within Organisation X and Y

This research highlights the extreme pressure both Organisation X and Y faced with regard to the UK government initiative to modernise pathology services. This external pressure was observed to potentially influence all three morphogenetic cycles. From a people perspective, the government drive to centralise laboratory services, would by default require staff to transfer into a new organisational setting. Structurally this would significantly influence roles, status, hierarchy and power relations within the organisation. Culturally, the pathology modernisation agenda was clearly premised on facilitating multi-disciplinary working and breaking down departmental barriers both within and between individual pathology departments.

According to Dr Rachel Leibman, Registrar of the Royal College of Pathologists, the adoption of LSPA was however simply a “defence mechanism” (Leibman, 2010) against the oncoming pathology modernisation agenda. In this respect the influence of government is considered to be a form of ‘coercive isomorphism’ (DiMaggio and Powell, 1983, p.150) generated as a result of ‘formal and informal pressures exerted on organisations by other organisations, upon which they are dependent and by cultural expectations in the society within which organisations function’ (DiMaggio and Powell, 1983, p.150).

The strategic decision to select LSPA as part of an MSP, rather than adopt less expensive stand-alone instrumentation, has significant financial ramifications.

For example, the 10-year MSP within Organisation Y will cost the Trust and hence the public purse over £30 million pounds. Nationally, the 'defence' against pathology modernisation, could actually cost considerably more than the £250-500 million it was intended to save.

This research supports the view that the procurement of LSPA was undertaken within both organisations as a strategic 'defence mechanism' (Leibman, 2010). Within Organisation X and Y support for the modernisation agenda centred on the opportunity of both organisations to become a large 'hub' site rather than the threat of becoming a small 'spoke' as transcripts from the following internal documents highlight:

> *'once in place, the extension in workload is easily accommodated therefore expansion of services for additional work from neighbouring SHA's etc. is possible with minimum increase on resource expense (income generation). The commercial opportunity is dependent on the development of PBR, the national tariff, transport issues and the competitive environment' (Organisation X, 2006).*

> *'Early talks have centred on the consolidation of 'cold' GP work within the region which would have a major financial impact on direct access income for Organisation Y with some 60% of the entire pathology workload coming from primary care. The Modernisation group have also discussed the possibility of reducing regional pathology overheads (human resources, finance, IT and logistics) but it is difficult to see how this would be achieved if* Organisation Y *was assigned as a spoke and not a hub' (Organisation Y, 2010f).*

The selection and implementation of LSPA technology within both Organisation X and Organisation Y is viewed as a means of reconfiguring services internally not consolidating within a network. This last observation ultimately had significant ramifications for the regional pathology modernisation agenda.

8.3.2 Cycle 1 Socio-cultural Interaction within Organisation X

This research has highlighted that once a technology is implemented, users start to perform organisational routines, which in turn are influenced by elements identified during social conditioning phase. In the social interaction phase users were exposed to the affordances and constraints of LSPA technology. The specific design features required to facilitate multi-disciplinary working i.e. a single automated platform, coupled to a central point of specimen loading and integrated middleware were observed to both afford and constrain human agency in practice. As a result humans in conjunction with external management consultants and managers applying lean tools and techniques were observed to modify their routines in order to devise specific 'workarounds' to overcome the material constraints of the system.

8.3.3 Material affordances and constraints of LSPA technology

Within Organisation X, changes in operational routines were required to ensure specimen data entry was completed prior to specimen processing. The failure to achieve the 'intended capture of agency' (Pickering, 1995, p.22) resulted in either over performance within the reception area and hence a build-up of specimens awaiting analysis, or conversely under-utilisation of the technology. In practice, both of these factors delayed specimen analysis, which ultimately created variation in result turnaround times.

Secondly, the material constraints of the individual transport pucks on the track, coupled to the positioning of multiple barcodes readers to sense the presence of specimens also caused significant problems. In this respect the materiality of barcodes are analogous to 'door hinges' in Latour's (1992) 'missing masses'. In both organisations, the material constraints of a single integrated tracking system required another workaround, which involved re-labelling up to 30% of all specimens received via the order comm request route. The introduction of this workaround again created delays in specimen result turnaround times and posed a significant clinical risk to patients.

The third change to organisational routine, identified during the course of this research, involved the processing of urgent samples. As a result of the delays in specimen processing identified above, staff within Organisation X bypassed the single automated platform and central loading point altogether and instead loaded specimens manually onto the system.

According to Horrocks (2009, p.59) a fundamental drawback of the social realist approach involves ‘specifying the context’ and establishing the character of causal mechanism, because neither ‘contingency/emergence’ nor ‘properties/mechanisms’ are directly observable. Second order emergents are considered to be experienced as operational obstructions and practical problems affording or constraining human agency.

Within the context of this research the inclusion of the sociomaterial concept of material affordances and constraints, into the social realist framework, has facilitated identification of the nature and character of the causal mechanisms, without relying on the observation of second order emergents, such as increased specimen turnaround time.

The identification of sociomaterial affordances and constraints ‘in-practice’ could potentially have significant practical ramifications for the design and innovation of new fixed form technologies. In order to realise this potential however it will be necessary to form much stronger collaborative relationships with the designers of technology, and this issue will be explored in detail later on in the chapter.

8.3.4 Cycle 1 socio-cultural elaboration within Organisation X

According to the primary supplier of the LSPA system, the introduction of the technology was designed to facilitate multi-disciplinary working and further utilise laboratory support staff. In respect to changes in staffing structure within Organisation X, these aims were only partially met in practice. Ultimately the introduction of the LSPA technology did lead to the development of new roles for support staff. These changes included the introduction of the role ‘runner’ to facilitate the smooth operation of the single piece flow system. The introduction of the LSPA also required the introduction of a comprehensive training programme to develop support staff. This developmental programme facilitated the use of the technology by support staff in both organisations and in so doing introduced a form of ‘multi-disciplinary working’, in line with the primary suppliers design intentions. In essence the sociomaterial impact of LSPA technology initiated structural morphogenesis within Organisation X.

Within Organisation X, however, more radical changes to staffing structure were not implemented at this time. As noted previously in the literature, capacity within UK pathology laboratories rarely matches demand (Pasmore, Petee and Bastian, 1986; Papadopoulos and Merali, 2008; Papadopoulos, Radnor and Merali, 2011). This phenomenon is especially apparent during the ‘non-core hours’ period (17:00-9:00), as reduced staff numbers deal with the logistics of late deliveries from GP surgeries. A significant factor for this mis-match of capacity and demand, unidentified in the literature, involves the payment mechanism for biomedical scientist staff. Traditionally biomedical scientist remuneration for working ‘non-core hours’ was covered by locally agreed terms and conditions. These payment agreements had been established over decades and accounted for a significant portion of the biomedical scientist salary. Leonardi and Barley (2008, p.171) state that it is important to understand the role of technology in pushing organisational practice in 'one direction rather than another, if for no reason than an alternative practice is 'too difficult or costly' (Leonardi and Barley, 2008, p.171). Any changes to working patterns would require significant renegotiation. The issue of resistance to change was so strong that the re-structuring of biomedical scientist staff was not addressed within either Organisation X or Y during the course of this research.

This observation is important because, although multi-disciplinary training and development of support staff was accomplished, the staffing establishment of biomedical scientist remained static in both organisations. Maintaining the 24/7 shift system required the same complement of biomedical scientist staff pre and post introduction of the LSPA. This research highlights that although the design intention of 'multi-disciplinary' working was accomplished to a degree, the design implication of reducing overall staff numbers was not achieved at this point in time. During this course of this research it is argued that an inability to bring about cultural change resulted in cultural morphostasis occurring during the elaboration phase. According to Mutch (1999, p.488) the morphogenetic cycle is completed by an assessment of the sociocultural elaborations or outputs highlighted above. These new sociocultural elaborations are then considered to form part of the sociocultural conditioning in the next running of the cycle. Observation of the effects of these structural elaborations within Organisation X was however not possible during the course of this research as the researcher/manager was transferred from Organisation X to Organisation Y.

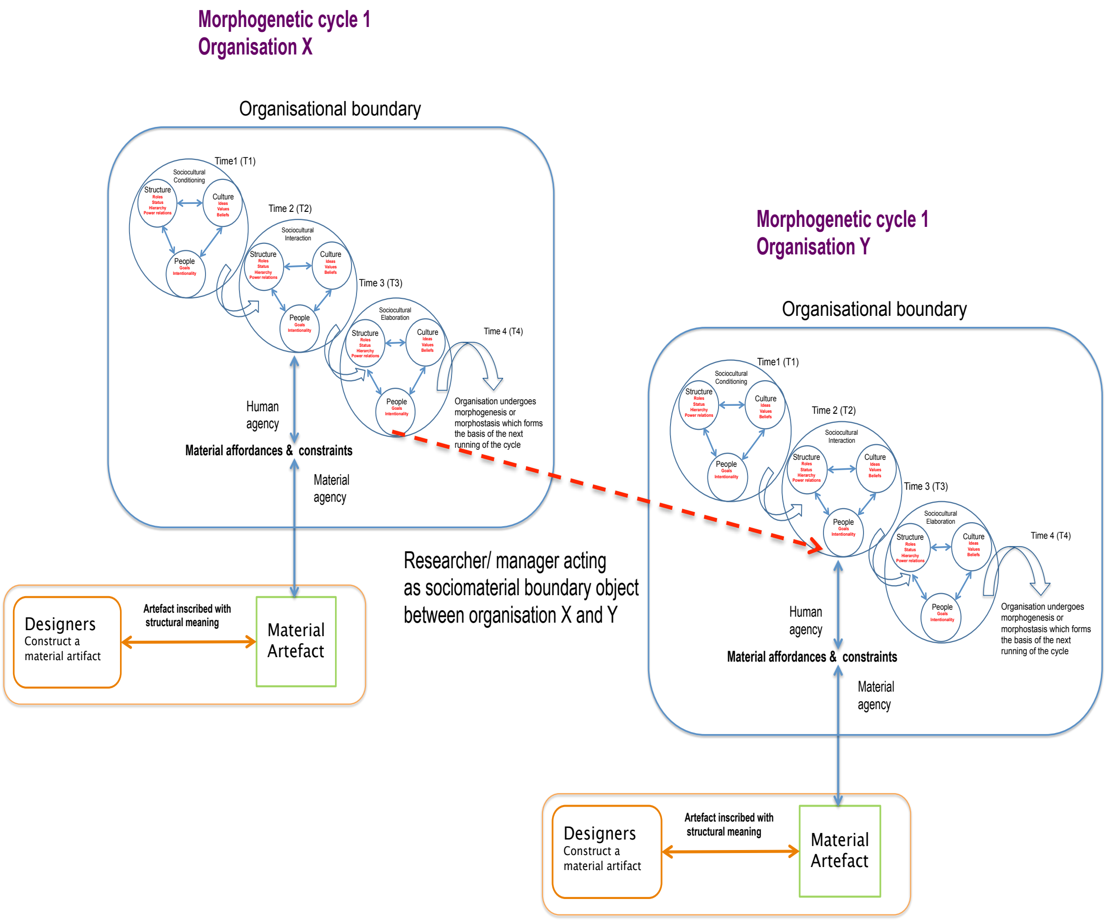
8.3.5 Managerial transfer from Organisation X to Organisation Y

Upon my arrival in Organisation Y, I as researcher manager observed that the materiality of the LSPA system purchased by Organisation Y had constrained working practices in an analogous fashion to those observed in Organisation X. The imbedded design features of the single automated platform coupled to the central point of loading and integrated information system had created significant operational problems, which resulted in delayed specimen processing.

In order to address these problems I utilised the organisational learning developed from Organisation X and together with management consultants from the primary supplier HCS team implemented similar changes within Organisation Y. Perhaps unsurprisingly, the impact of the changes once again created a ‘dialectic of resistance and accommodation’ (Pickering, 1995, p.22). The organisational changes required to facilitate specimen data entry prior to analysis, coupled to similar difficulties with the barcode labelling of specimens, created problems of under and over production within the central reception area of Organisation Y. In essence the sociomaterial configuration that had been observed to create operational difficulties within Organisation X had been transferred across organisational boundaries to Organisation Y. It will be argued during the course of this discussion that in my capacity as researcher manager I acted as a sociomaterial boundary object, the effects of which significantly influenced the homogeneity of working practices across both sites.

The first phase morphogenetic cycle occurring in Organisation X and subsequently transferred to Organisation Y is diagrammatically illustrated below:

Figure 18 Morphogenetic cycle 1 occurring in Organisation X and subsequent transfer to Organisation Y.



As a consequence of my managerial transfer from Organisation X to Organisation Y, the following section of this discussion will concentrate on two further morphogenetic cycles occurring in the latter organisation and initiated as a result of increased external government pressure in the form of pathology modernisation.

8.4.1 Cycle 2 socio-cultural conditioning - the formation of N.E. Path.

Within the North East of England, the influence of the pathology modernisation agenda began to gain momentum with the formation of the N.E. Path modernisation network, of which Organisation X and Y were both founder members. In addition the CEO and clinical director of N.E.Path were also the CEO and clinical director of pathology within Organisation X. It must also be noted at this point that Organisation X had already implemented the introduction of a single track LSPA, considered during the course of this research to embody the intentions of pathology modernisation in material form. The sociomaterial configuration within Organisation X and the socio-political influence of the clinical director of pathology and CEO placed the organisation in a very strong position to be viewed as a pathology 'hub' rather than 'spoke' and hence direct competition to Organisation Y.

At this point no discussion or decision had been made as to exactly how many hubs and spokes there would be in the region, but tensions were obviously beginning to rise.

8.4.2 Cycle 2 socio-cultural interaction – HCS team involvement in structural reconfiguration

As Lead Biomedical Scientist within Organisation Y, I gathered together a group of senior managers to discuss the issue of reconfiguration of pathology services. As a result of this work, four internal review documents were produced (Shaw, 2010c; Organisation Y, 2010f; 2011b; 2011c) each highlighting the fact that all three individual sites, within Organisation Y, appeared to have their own affordances and constraints, with regard to centralisation of pathology services. Essentially the sociomaterial configuration within Organisation Y revealed that none of the three available sites were an ideal candidate for internal centralisation based on the 'hub' and 'spoke' model.

During these early discussions it became acutely apparent that the wider sociomaterial affordances and constraints of the LSPA were also creating significant issues. I consider the organisation of pathology services within Organisation Y to be unique, in that both Urban 1 and Urban 2 are equipped with the same dual tracking systems for haematology and biochemistry i.e. four tracks in total. The provision of two identical LSPA systems, on two sites, results in significant over capacity to cope with current levels of demand, although it does provide affordances with regard to business continuity planning.

8.4.3 Influence of External management consultants

During this period of the research, a senior member of the primary supplier HCS team and I contributed to an extensive project to evaluate the current and potential future staffing structures utilised within the laboratory (primary supplier, 2011b). Following discussions with senior management, the HCS team and I were aware of the intention to review pathology services within Organisation Y across all three sites. The HCS team then suggested a willingness to review capacity, demand and productivity across the entire pathology process. In essence the primary supplier HCS team were willing and able to be directly involved in the rationalisation of pathology services and hence intimately involved in directly influencing potential structural changes within the department.

This analysis included a review of GP specimen referral patterns and relative demand from each GP practice, together with an assessment of logistics for specimen transportation, together with the production of an in depth capacity and demand model (Primary supplier, 2011b). This work primarily utilised data collected from the LSPA database. In this respect the data was used to 'informate rather than automate' (Zuboff, 1988, p.8). As a result it was calculated that the entire current workload within Organisation Y, could theoretically be undertaken at one of the two sites, i.e. on one set of LSPA rather than two. Conversely this increased capacity offered the opportunity to cope with a significant increase in demand, if Organisation Y were selected as a pathology ‘hub’ within N.E.Path.

It is suggested that, in addition to purposefully intending to influence staffing structures through the design of technology, the primary supplier management consultants were also willing to be openly involved in directly influencing other elements of the structural cycle. The influence of the HCS team together with management representatives from Organisation Y would eventually be observed to challenge existing power relations and corporate goals. In doing so, it is argued that the resulting sociomaterial configuration, allowed management consultants to function as sociomaterial boundary objects operating internally within Organisation Y and across the organisational boundary between designers and users of LSPA technology. The impact of HCS management consultants as human boundary objects will be further investigated below.

8.4.4 Human boundary objects

Star and Griesemer (1989, p.410) originally defined ‘boundary objects’ as an object ‘which lives in multiple social worlds and which has different identities in each’. A boundary object is then considered to be ‘a sort of arrangement that allows different groups to work together without consensus’, or ‘organic infrastructures’ arising from ‘information and work requirements as perceived locally and by groups who wish to cooperate’ (Star, 2010, p.602). It has already been acknowledged during this chapter that boundary objects and the concept of sociomateriality share a similar theoretical positioning with regard to performativity as highlighted by Star (2012, p.603) below:

'The words "boundary" and "object" may need some explaining, as well. Often, boundary implies something like edge or periphery, as in the boundary of a state or tumour. Here, however, it is used to mean a shared space, where exactly that sense of here and there are confounded. These common objects form boundaries between groups through flexibility and shared structure – they are the stuff of action'

Being the 'stuff of action' (Star, 2010, p.603) suggests that a boundary object may be conceptualised as an enactment of social and the material in becoming "sociomaterial" in practice.

Carlile (2002, p.451) goes onto define three types of knowledge boundary operating at three levels of increasing complexity. Firstly a boundary object is considered to establish a shared 'syntax' or 'language for individuals to represent their knowledge'. Secondly objects operating at the semantic boundary provide 'a concrete means for an individual to specify their differences and dependencies' as exemplified by 'standardised forms and methods' (Carlile, 2002, p.451). Thirdly at the pragmatic boundary an effective boundary object 'facilitates a process where individuals can jointly transform their knowledge' (Carlile, 2002 p.452). Working at the pragmatic boundary however requires 'domain-specific knowledge' as well as 'common knowledge' (Carlile, 2004, p.559). An effective boundary object must then display a political quality where 'current and novel forms of knowledge' can be jointly transformed producing more shared knowledge at the boundary (Carlile, 2002, p.453).

Within their original definition of boundary objects Star and Griesemer (1989, p.411) highlighted that marginal people shared many similarities with the concept of boundary objects. Although the potential for humans to act as boundary objects was ultimately dismissed by Star and Griesemer (1989, p.412) on the grounds that marginal humans were considered to be 'volatile' and 'elusive', other scholars including Zdundczyk (2006) have challenged this perspective. Zdundczyk (2006) argues that marginal people such as 'management consultants or interim managers' share similarities with boundary objects, by virtue of their 'partial and simultaneous, membership of different social worlds'. Management consultants and interim managers are then considered to be characterised by 'internal heterogeneity' which allows members of a group to view them in different categories, while still retaining a common identity. With regard to this research management consultants acted as more than just technical advisors. Armed with tools and techniques developed from lean manufacturing principles, members of the HCS team worked for protracted periods of time with users of LSPA technology in a manner analogous with ethnographic research. In doing so HCS consultants were observed interacting with users 'in practice' to identify local problems and localised resolutions on a micro scale. Importantly working at the pragmatic boundary, HCS consultants are considered to have domain specific knowledge, which allows 'different groups to work together without consensus' (Star and Griesemer, 1989, p.410). This factor is highlighted by the HCS team involvement in the production of strategic documents, which passed between users, managers and corporate actors. HCS consultants acting as human boundary objects ultimately had an influence the on the corporate decision to either rationalise services internally or consolidate pathology services within the regional network.

HCS consultants acting as human boundary objects also offer the potential to influence the design of technology and as such represents a significant bridge between design and use.

The identification of localised material affordances and constraints 'in action' leads to the potential to feedback this knowledge to the design team within the supplier organisation, which should influence future technological innovations. For example, it is highly unlikely that designers of LSPA technology could adequately conceptualise how the materiality of LSPA would impact organisational routines in practice, within a pathology laboratory, where demand for services vary throughout the day. Following implementation of LSPA the HCS team were called upon to investigate the capacity and demand issues. In addressing these issues organisational routines were modified. However there is a potential that observing the material affordances and constraints in practice could lead to a re-design of the technology. Observations made in practice by HCS consultants could provide a channel to investigate potential solutions collaboratively with users. For example within both Organisation X and Organisation Y the issue of poor quality or misaligned barcodes created significant delays in processing and introduced a degree of clinical risk into the process, which has gone unaddressed for five years. As a result of this problem, system users are required to re-label up to 30% of all specimens entering the laboratory via the order comm route. The identification of this significant constraint, created by the positioning of multiple barcode readers and the materiality of the transport pucks obscuring misplaced barcodes, requires immediate attention from the design team.

8.4.5 The identification of macro scale affordances and constraints

During the course of this in depth analysis undertaken by the HCS team and system users, the significant affordance offered by LSPA technology were countered by three sociomaterial constraints. Firstly, LSPA are physically huge pieces of equipment and their transfer across site or removal would not be an easy or cheap option. Secondly the contractual arrangement agreed with the primary supplier over a ten-year period, as part of a MSP itself became an affordance and constraint. It was made perfectly clear during negotiations with the primary supplier that significant changes such as the removal of an entire LSPA platform would breach the terms of the MSP and hence would attract significant financial penalties. Smaller modifications however would be possible and were supported by the primary supplier; these include relocation of pieces of technology or substitution for larger or smaller analysers appropriate to workload. These modifications are made possible because the technology itself is only relatively ‘fixed function’ (Orlikowski, 1996, p.90)

Thirdly, although the LSPA technology was designed to facilitate multi-disciplinary working by support grades of staff, in practice this option was not considered clinically desirable. On-going problems with the technology resulted in a series of serious untoward incidents both as a result of human and technical error. These issues resulted in senior managers within biochemistry lacking confidence in the system. As a result, senior managers were unwilling to consider centralisation of services and the increased use of unsupervised support staff to operate the LSPA. In essence the primary suppliers desire to facilitate ‘multi-disciplinary working’ and reduce biomedical scientist head count, could not in this instance be realised in-practice.

From a design perspective it became apparent that not all of the individual pieces of automation attached to the LSPA system were at the same stage of maturity, a fact acknowledged by the supplier during the course of the interview process as highlighted below:

> *‘You have to remember that the primary supplier portfolio right now is really instruments around three different major companies, so they don’t look and feel the same when you look at the user interfaces, just because of where they came from. You can remove that objection by using the common middleware for review and edit’. (S1).*

Indeed the development of a central user interface to link the individual pieces of technology was introduced to bring a degree of homogeneity across the analytical platforms.

This design change however could not belie the fact that some of the analysers were decidedly less ‘walkaway’ than others and hence, from an operational perspective, required much more intensive maintenance by qualified scientific staff rather than support workers. However, once again the identification of these deficiencies should lead to improved design if these problems are relayed back to the design team in an appropriate manner via the HCS consultants.

8.4.6 Cycle 2 sociocultural elaboration

From a morphogenetic perspective, the second phase interaction, which included the HCS involvement within the structural cycle, ultimately resulted in structural and cultural morphostasis. Although socio-cultural interaction did not bring about any formal changes it did however succeed in raising awareness of the issues. Dialogue between primary and corporate agents, provided the space for interaction and provided a richer picture of the impact of technology. An appreciation of these factors included a better understanding of broader social structures such as power relationships, which ultimately impacted on the strategic decision making process. For example as highlighted above as a result of the second cycle sociocultural interaction, the HCS team undertook a review of GP referral patterns, logistics and relative demand from each GP practice (Section 7.7). This work was undertaken primarily to consider the impact of any service change on GP pathology result turnaround times. Following the publication of the white paper ‘Equity and Excellence: Liberating the NHS’ (Great Britain. Department of Health, 2010c; 2010d) healthcare budgets were deferred to GP practices rather than NHS Trusts. As a consequence of these changes GP's would be directly responsible for purchasing services including pathology from any qualified provider, from either the public or private sector. Within the structure of the 'new' NHS, GP's became instrumental in the decision making process on behalf of patients and as a result highly powerful. Any perceived deterioration of the delivery of pathology services by the GP population, could potentially result in in up to 60% of the entire pathology workload (section 7.9) being delivered by another provider, together with the associated loss of income for Organisation Y.

Secondly the work undertaken by the HCS team also identified internal power relations, in operation within Organisation Y. Geographically urban 1 was seen as being better placed within the North East of England that urban 2. As a result of this fact urban 1 is better able to attract and retain clinical staff to work at this site than urban 2. The impact of clinical resistance to re-locate pathology services onto the urban 2 site was then seen as a significant factor in the decision making process (section 7.9).

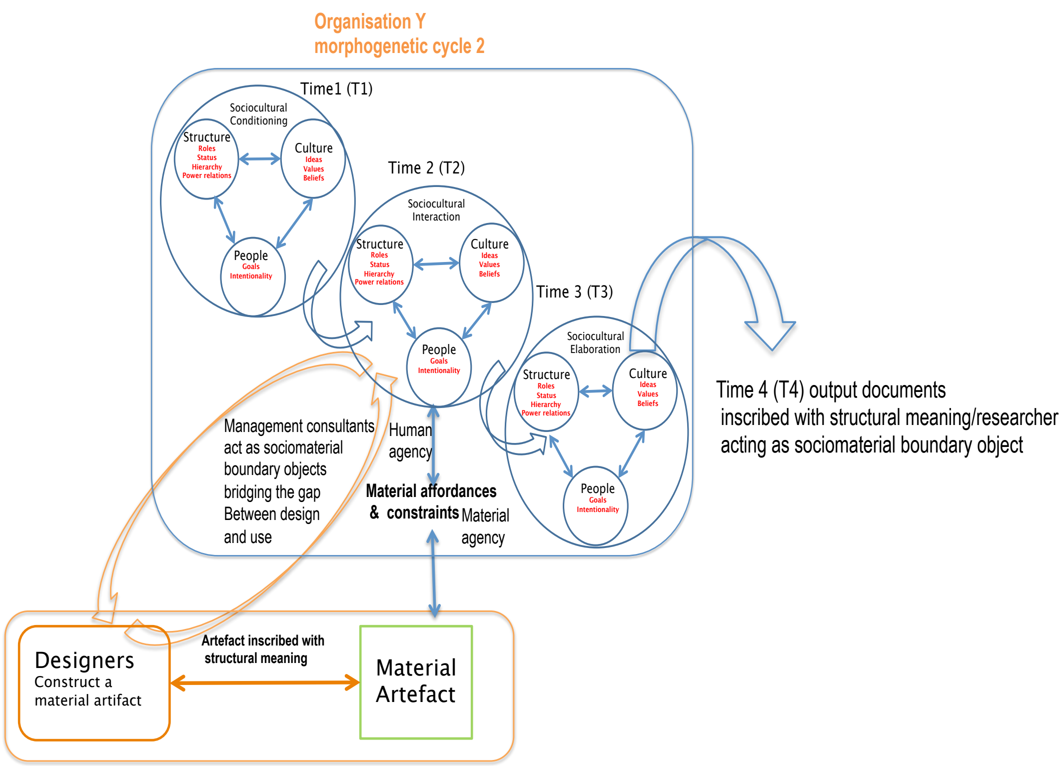
8.4.7 Interim managers as sociomaterial boundary objects

During 2011, I was appointed as Head of Diagnostics within Organisation Y and utilised the knowledge and learning gained from the above process to produce a review document (Organisation Y, 2012c) for corporate actors within Organisation Y.

This document, produced in conjunction with the learning gained in collaboration HCS team, highlighted the material affordances and constraints of the technology, from both a micro and macro perspective. As such this artefact acted as a boundary object inscribed with structural meaning, transferring knowledge between users, managerial agents and corporate actors.

The issue of humans acting as boundary objects has already been highlighted earlier in this chapter, with regard to the influence of management consultants. In this instance, the sociomaterial interaction of the researcher, as a marginal interim manager and the material document inscribed with structural meaning, allowed facilitated dialogue across the user/corporate boundary. In turn this relationship developed organically and allowed the two groups to cooperate without consensus, as the sociomaterial boundary object moved back and forth between both groups, a situation that still exists to this day. A diagrammatic illustration of the second morphogenetic cycle observed within Organisation Y is highlighted below:

Figure 19. Organisation Y - morphogenetic cycle 2



8.5 Cycle 3 – Sociocultural conditioning

The review document produced as an output of the second phase morphogenetic cycle was subsequently presented to corporate managers within Organisation Y. Although I presented three service model options to the executive group, (Organisation Y, 2012c) knowledge of the sociomaterial affordances and constraints of the LSPA technology influenced my decision as to the potential solution to the problem. I perceived the potential solution as being that of limited internal rationalisation, based on the clinical needs of patients. In essence rather than shape Organisation Y to fit the N.E.Path network ideal of a single 'hub' laboratory, a more patient focused, cost effective service could be realised by rationalising internally. In doing so this collaborative approach to change would be based on clinical need rather than political impetus. The corporate group accepted my attempt at 'problemisation' and agreed to support the option of limited, internal rationalisation rather than wide-scale consolidation as part of N.E.Path.

8.5.1 Cycle 3 sociocultural interaction – CEO involvement in transformation process.

Following the production of this document, a third round of sociocultural interaction was observed to take place when the CEO addressed pathology staff directly, utilising a presentation produced by myself for the event. During this presentation and subsequent conversation, the CEO openly discussed concerns regarding the N.E.Path initiative, especially with regard to the proposed financial savings, estimated at the time to be £2 million per Trust (Organisation Y, 2012d). It was acknowledged at this point that the majority of these cost savings would be made by wide-scale job loss and as such posed a major threat to staff. Staff were made clearly aware, however, that internal reconfiguration would also have to result in significant cost savings, estimated at £400, 000.

Following discussions with staff over the advantages and disadvantages of internal re-configuration or external consolidation, the CEO presented staff with a challenge that I considered at the time to be a radical departure from the norm. During this presentation the CEO openly stated that she considered internal rationalisation as the preferred option. However, rather than impose change from the 'top down', the CEO offered staff the chance to consider both alternative options and decide for themselves which direction the organisation would take with regard to pathology services. This was not an open ended offer, the CEO stated that staff were required to make a decision on the fate of pathology services within three months and that she would need to be convinced that the requisite savings could be made internally. The default position would therefore be the decision of the CEO to engage with the N.E.Path network

According to McLean and Hassard, (2004, p.494) the actor network is realised through engaging or 'enrolling' human and non-human participants into an emerging network through a process of 'negotiation and translation'. The 'enrolment' of actors as constitutive elements of that network involves the establishment of an 'obligatory passage point' (OPP) which entails setting conventions, rules, assumptions and ways of acting that have to be followed by constituent members' (Papadopoulos and Merali, 2008, p.42). This is considered an important element in articulating 'conscious commitment of actors to specific networks' with associated 'explicit and visible conditions for coherence within the network' (Papadopoulos and Merali, 2008, p.42).

In this respect the CEO attempted to ‘enrol’ staff into the laboratory actor network by offering them a role in the decision making process, through a collaborative management style. The CEO herself would then constitute the OPP, as once the decision to rationalise internally or not had been made, that decision would be final.

Within the social realist concept of emergence and stratification laboratory staff were initially considered to function as primary agents, identified by their ‘lack of say in structural and cultural modelling’ (Horrocks, 2009, p.41). Importantly within the context of this research, a deeper understanding of sociomaterial affordances and constraints technology coupled to a collaborative management style resulted in the ‘primary agents’ being mobilised into ‘corporate agents’ capable of influencing both the structural and cultural morphogenetic cycles. In essence users of LSPA systems became involved in the design cycle and as such they were capable of influencing organisational routines and strategy.

In this example ‘mobilisation’ (Kaghan and Bowker, 2001, p. 258) was considered to have occurred when staff groups confirmed, in a series of three independent presentations, that the decision to enter into internal negotiations was the preferred option of the majority (Organisation Y, 2012j; 2012k; 2012l). This was a profound decision, which effectively meant that Organisation Y would no longer engage with the regional pathology modernisation group and hence signalled the demise of the concept of a formally managed pathology network within the N.E of England.

The review undertaken by the users of LSPA technology ultimately supported centralisation of cold work at urban 2 as an ‘acceptable option’ (Organisation Y, 2012l). Staff also confirmed in their plans that internal rationalisation held the potential to ‘reduce duplicate kit’ (LSPA) and offered significant opportunities to ‘review skill mix’ (Organisation Y, f). The principle concerns were documented as ‘sample viability’ ‘transportation’ and ‘late production of results’ (Organisation Y, 2012l). These concerns relate to service provision to GP surgeries and reconfirm the influence of power from the GP community highlighted earlier in this chapter.

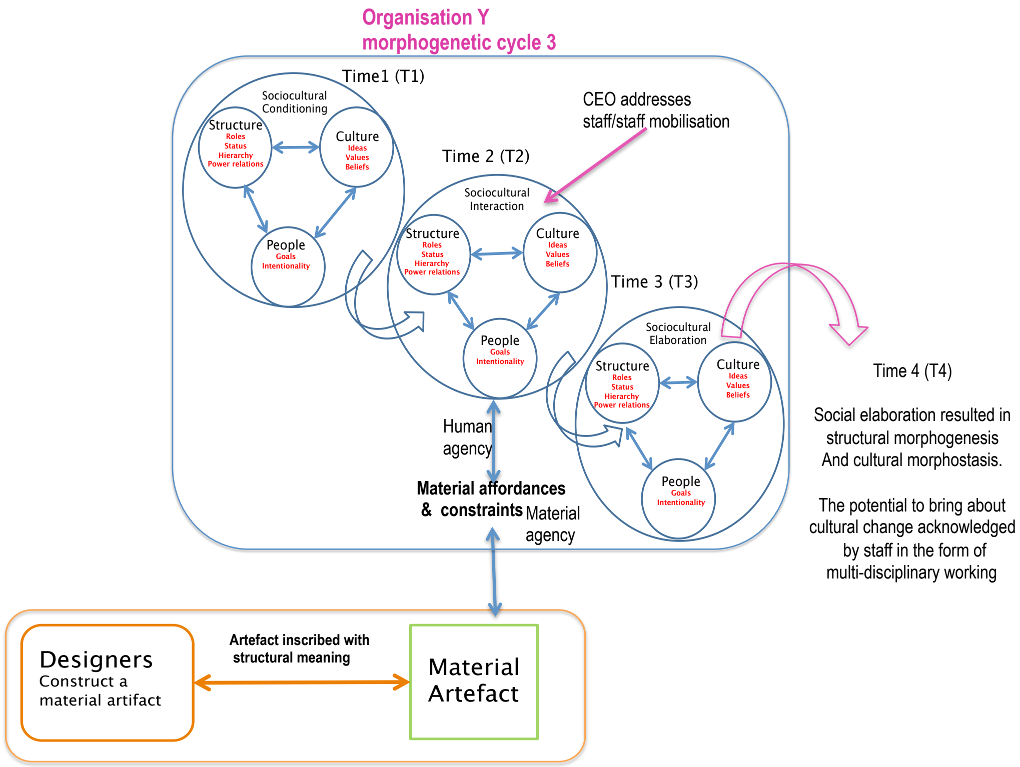
An unexpected outcome of the discussions raised by pathology staff was the opportunities afforded by multi-disciplinary working. Within the biochemistry and haematology departments, multi-disciplinary working was seen as ‘desirable for support staff’ but ‘not feasible at this time for biomedical scientist staff, due to reduced staff numbers and depth of knowledge required’. However the concept of multi-disciplinary working was not ruled out entirely and it was suggested that this should be a ‘much longer term project’ (Organisation Y, 2012l).

8.5.2 Cycle 3 structural and cultural elaboration

According to Horrocks (2009, p.40) the morphogenetic cycle sets out the conditions under which ‘change or reproduction’ is likely to occur ‘in social, structural and cultural contexts’. When structural and cultural changes are synchronised the effect between the two are considered reciprocal and generative. Conversely when they are out of sync one will be more consequential for the other ‘temporally and temporarily’ (Archer, 1995, p.308). Consequently change or morphogenesis occurring within the structural cycle, accompanied by ‘morphostasis’ (Archer, 1995) in the cultural cycle, will be short lived and unsustainable.

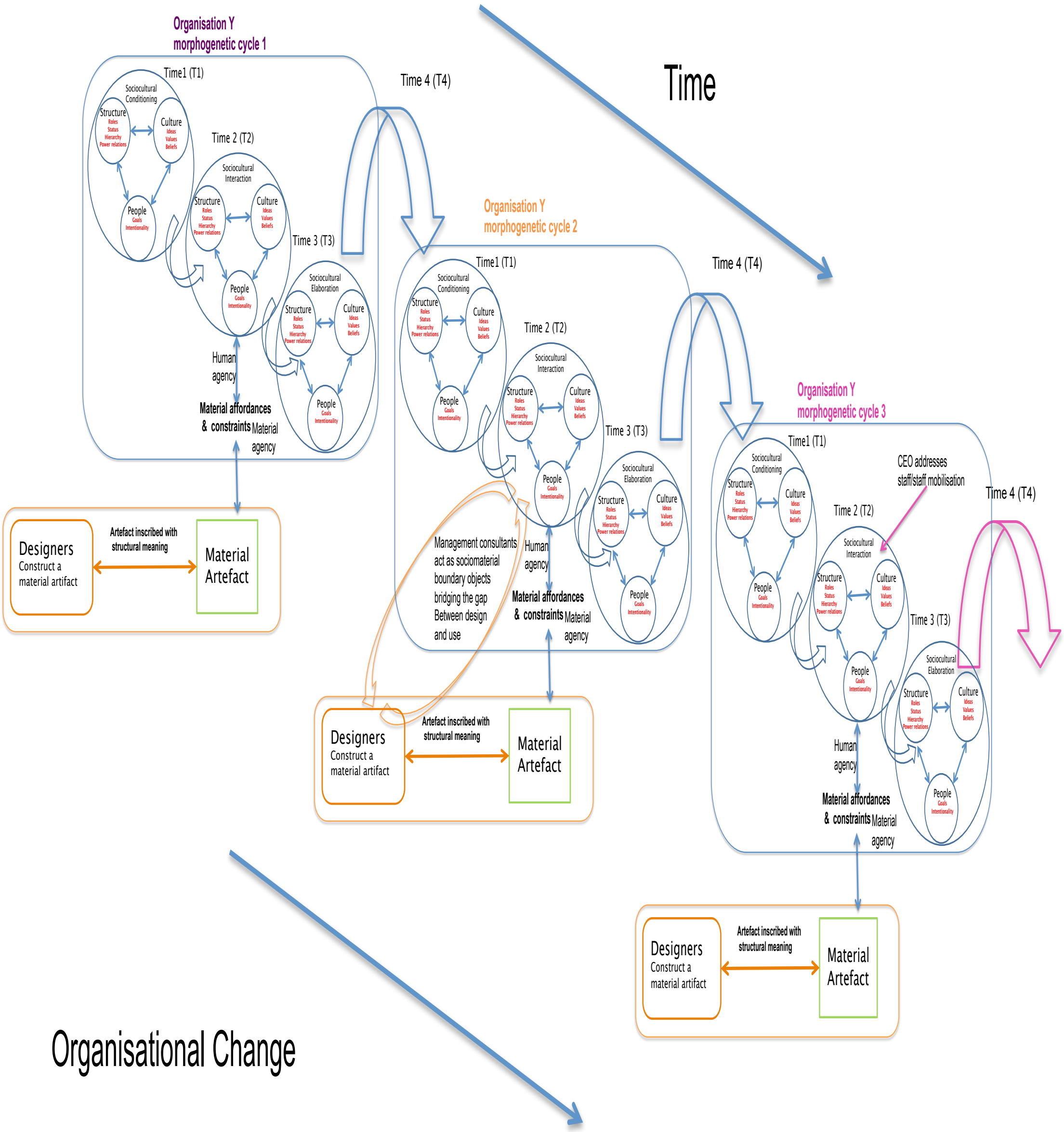
Within the context of this research a co-operative management style, which led to the emergence of ‘primary agents’ into ‘corporate agents’ resulted in proposed changes to both the structural and cultural cycles. Structurally, staff acknowledged that changes to skill mix and the development of support staff would offer significant efficiency advantages and hence structural morphogenesis would appear to have taken place. From a cultural perspective it is suggested that the ‘ideas, theories, beliefs and values’ (Archer, 1995, p.179) of users of LSPA are also beginning to change. Although staff acknowledged that this will be a slow process and culturally the organisation would still appear to be in a morphostatic phase, there would appear to be at least the potential to change. From a practical perspective an acknowledgement that the introduction of technology may result or require cultural change would appear to be of significance. A diagrammatic representation of the third phase morphogenetic cycle is illustrated below:

Figure 20 Morphogenetic cycle 3 in operation within Organisation Y



It was acknowledged at the beginning of this chapter that research into the sociomaterial influence of LSPA couple to key tenets of the morphogenetic approach and ANT would be complex and multi-faceted and indeed that has proven to be the case. The practical application of the sociomANTerial model has been utilised to investigate organisational change over time within Organisation Y. Uniquely the development of the sociomANTerial model has been able to provide a historic record of these changes which results in a depth of analysis previously unobtainable within the confines of other sociomaterial configurations. A cumulative model of the change process within Organisation Y is highlighted in Figure 21 below:

Figure 21 The impact of LSPA technology over space and time within Organisation Y



8.6 Summary

Since this research began, the concept of sociomateriality has developed into a heterogeneous body of work. A critical review of the literature revealed that none of the existing frameworks appeared to adequately address the influence of fixed function technology, such as LSPA, with regard to the effects of time and broader social structures such as power. In order to address these deficiencies this research has suggested that a hybrid theory based on the 'morphogenetic approach' (Archer, 1995), coupled to key tenets of ANT (Latour, 2005) may overcome many of these perceived limitations.

The development of the resulting sociomANTerial model revealed that design features inscribed within the material properties of LSPA, were purposefully intended to bring about changes to organisational structures and routines. In both user organisations material affordances, which included a perceived ease of use, resulted in anticipated skill mix changes. Material constraints within LSPA were however observed to create operational difficulties, which were subsequently transferred across organisational boundaries by the researcher/ manger. The identification of these sociomaterial affordances and constraints, revealed deep generative mechanisms, which in conjunction with humans, acting as boundary objects, had the unintended consequence of influencing strategic decision making and initiating structural and cultural change.

The practical application of the resulting SociomANTerial model allowed the researcher to trace the analytical history of these organisational changes over time and consider the impact of broader social structures such as power. Ultimately it is suggested that collaboration between users, designers and corporate agents will result in innovative technology and improved organisational design.

Chapter 9 Conclusions

9.0 Introduction

The original concept of sociomateriality based on the ‘agential realist’ perspective developed by Karen Barad (2003) posited that agency or ‘free will’ does not reside in either the material or the social elements of everyday life. Instead the social and the material are perceived as being ‘constitutively entangled’ (Orlikowski, 2007, p.1437) in practice. This ‘profound conceptual shift’ (Barad, 2003, p.815) replaces the idea of materiality as ‘preformed substances’ with that of ‘performed relations’ (Orlikowski, 2007, p.1437). In considering all relationships to be ‘mutually constitutive’ however this denies the influence of time and overlooks how and why phenomena get put into relationships in the first place. As a result of this criticism the agential realist perspective is considered to create difficulties for researchers wishing to undertake empirical study and to also potentially lack a unique explanatory power over more established social theories such as STS or ANT. This research aims to advance our understanding of the impact of materiality on society by utilising the morphogenetic approach of Archer (1995) underpinned by key tenets of ANT, to develop a model with which to explore how sociomaterial networks involving large-scale automation come into being, persist and change over time, within a healthcare environment.

In this chapter, the contributions to theory and practice are discussed, followed by a review of the originality of this research. The perceived limitations of this work will be identified and followed finally by suggestions for future research.

9.1 Contributions

This work contributes to theory by developing a theoretical model to explore how sociomaterial networks, involving large-scale automation, come into being persist and change over time within a healthcare environment. This research overcomes perceived limitations of other conceptualisations of sociomateriality, including a lack of consideration of time and an under appreciation of broader social structures, such as power.

The development of the SociomANTerial model makes a second contribution to theory by considering the role of humans as sociomaterial boundary objects (Star and Griesemer, 1989; Star, 2010; Carlile, 2002; 2004; Zdundczyk, 2006). In doing so humans and material objects are conceptualised as enacting the social and the material in practice, allowing different groups of staff including users of LSPA technology and corporate managers to work together without consensus.

This research contributes to practice by utilising the sociomANTerial model to assess the impact of the introduction of LSPA within two UK NHS pathology laboratories. In doing so the work bridges the gap between design, implementation and use of technology within a healthcare environment. By developing a sociomANTerial model, which foregrounds the material affordances and constraints of technology it is suggested that collaboration between designers, users and organisational leaders will result in innovative technologies and improved organisational design.

This research makes a second contribution to practice by highlighting the importance of longitudinal ethnographic study in the identification of sociomaterial subsystems. It is argued that ethnographic study, which relies on protracted investigation 'in practice', provides a suitable medium with which to investigate 'deeper generative mechanisms' at play between users and the complex web of technologies, which I have considered under the 'umbrella' term LSPA.

9.1.1 Development of the SociomANTerial model

Utilising the morphogenetic approach developed by Margaret Archer (1995) the SociomANTerial model developed during the course of this research allows us to discuss how the social, structural and cultural elements of organisational life interplay without having to resort to determinism. Although separated analytically and temporally, the three interrelated cycles of emergence-interplay-outcome are continuous, thus the outputs of one cycle are considered to form the inputs of the next stage of the process. As a result the morphogenetic approach allows us to identify the conditions in which change or reproduction are likely to occur and allows us to produce an analytical history of the process.

The theoretical underpinning of critical realism allows us to identify that the introduction of technology predates action and pre-exists people's perception. The SociomANTerial model therefore overcomes theoretical concerns highlighted with the 'agential realist' (Barad, 2003) perspective of sociomateriality, which includes the absence of a theory of temporality. In doing so the SociomANTerial model acknowledges that although technology is presented to users as if it were 'natural' (Mutch, 2010, p.511), this is indeed far from the case.

Template analysis (Appendix 6) of the semi-structured interviews with members of the primary supplier design team addressed the two secondary research question highlighted below:

Do the developers of LSPA purposefully intend their technologies to shape the work practices of users or the structure of organisations?

If so how do designers of LSPA technology subsequently embody their intentions in designs?

The introduction of LSPA technology into user organisations was intended to change working practices and organisational structures. The primary design intention of the suppliers of LSPA technology was to facilitate 'multi-disciplinary working'. Within this context multi-disciplinary working was considered to take both a social and material form. From a social perspective 'multi-disciplinary' working refers to the ability of laboratory staff to have the knowledge and skills to operate in multiple pathology disciplines, for example biochemistry and haematology. In this respect multi-disciplinary working is analogous with the key sociotechnical systems (STS) concept of 'multi-functionality' as opposed to the 'multi-tasking' observed in lean production (Niepce and Molleman, 1998, p.266). The introduction of multi-disciplinary working was then perceived to breakdown cultural barriers observed previously in the literature both between and across individual pathology disciplines (Pasmore, Petee and Bastian, 1986; Valentine and Behara, 2001; Wainwright and Shaw, 2007; 2008; 2013).

From a material perspective, the introduction of LSPA was seen as a means of bringing together physically disparate disciplines onto a single automated platform.

Interview data obtained from the suppliers of LSPA technology identified that LSPA technology was inscribed with structural meaning. This research highlighted three key features, which embodied the primary supplier design intention to facilitate multi-disciplinary working. These features included the introduction of a single pathology platform (Design feature 1), a central loading point for specimens (Design feature 2) and a system of integrated middleware (Design feature 3) to control the entire platform from a single point of access. The materiality of the LSPA system was then designed to constrain human agency, which would in theory be reduced to loading and unloading large racks of specimens on and off the automated system.

At the same time however the SociomANTerial model acknowledges that individuals are reflexive and will use interpretive flexibility as they encounter new technology. Society is then considered to be an open system, which offers the potential for people to re-design and innovate. The social realist approach allows us to conceptualise the world as emergent and stratified being made up of layers emerging from each other but not reproducible to it. In so doing the sociomaterial model recognises the tripartite division of people into individuals, agents and actors each of which are defined by the roles and positions they hold in society, whilst acknowledging that these roles are not fixed and can change over time.

Within the SociomANTerial model technology is visualised by drawing on the concept of structural inscription utilised within Actor Network Theory (ANT). Essentially designers of technology are considered to inscribe their world-view into relatively fixed function artefacts, which then form the social conditioning of the next round of social interaction. According to Mutch (2002, p.479) ‘adopting ideas drawn from ANT could provide a useful complementary framework which needs further development’. This research makes a contribution to knowledge by incorporating ANT into the morphogenetic approach to gain a better understanding of the material impact of LSPA technology in a pathology environment. During the course of this research the identification of the material features designed to embed structures into user organisations has led to a better understanding of the design intentions of suppliers, and conversely a better understanding of what designers are trying to do to themselves. In doing so the model allows us to appreciate the theory of temporality within the framework as pre-formed technologies are introduced into the workplace. Within the SociomANTerial model however the application of ANT is extended to trace the ties in networks that develop during the course of this research. In doing so the model allows us to identify the impact of broader social structures such as power. During the course of this research the sociomaterial affordances and constraints of LSPA technology was seen to impact on both a micro and macro scale. The application of ANT allowed us to better conceptualise the impact of the UK government modernisation agenda on Organisation Y. A review of the literature revealed that technological determinism within a health care environment reduced technology to little more than a 'socio-political tool' (Nelkin and Andrews, 1999) to meet economic needs. The impact of adopting a collaborative leadership style to 'mobilise' pathology staff resulted in a service re-design focused on the needs of patients rather than simply complying with government directives.

Within the SociomANTerial model human agency is considered to revolve around the specific plans and goals arising from existing 'cultural predispositions' or 'imaginatively transformed visions of the future' (Pickering, 1995, p.19). According to Thomas (1994, p.12) the selection process can provide 'a wealth of information on the decision to adopt a particular technology'. In particular it is recommended that we pay attention to the 'alternatives considered but not selected' (Thomas, 1994, p.12). This research has then contributed to that body of knowledge by highlighting that managers involved in the selection of LSPA technology were significantly influenced by site visits. Managerial perceptions of material affordances and constraints of LSPA technology were seen to significantly influence the decision to select either single or dual track automation. The decision making process was however, seen to be influenced by the differing goals and aspirations of powerful individual managers to either maintain deep rooted cultural divides or to select technology as a socio-political defence against pathology modernisation.

Material agency within this model is conceptualised as affordances and constraints, which in essence involves the identification of what the material properties of a technology will or will not allow a user to do and the workarounds humans devise to overcome the latter. When faced with a technology that constrains human agency, users are then faced with three options; they can choose not to use some or all of the aspects of the technology, they can modify their work practices accordingly or they can make changes or suggest changes to the technology itself. The development of the SociomANTerial model reveals how collaboration between users, managers and designers can lead to improved organisational routines and innovative technological design in practice.

9.1.2 Sociomaterial boundary objects

This research makes a second contribution to theory by identifying the potential for management consultants and interim managers to act as human 'boundary objects' (Star and Griesemer, 1989; Star, 2010; Carlile 2002; 2004; Zdundczyk, 2006).

As highlighted during the literature review with a few notable exceptions, (Orlikowski, 1996; Thomas, 1994; Leonardi, 2011) previous research investigating the influence of technology on organisations has focused on either the design or implementation phase. During the course of this research it has been noted however, that within these three exceptions to the rule the design cycle has been investigated within a single organisation, which offers significant advantages with regard to study design. This research is then considered unique in that it has investigated the design cycle across multiple internal and external organisational boundaries. In order to transfer knowledge and learning across these organisational boundaries, humans in the form of management consultants and interim managers together with objects in the form of operational models inscribed with structural meaning have acted as a 'sociomaterial' boundary objects. In so doing this sociomaterial boundary object has been conceptualised as 'living in multiple social worlds and having different identities in each' (Star and Griesemer, 1989, p.410). Thus HCS management consultants have worked collaboratively with users, in a fashion analogous to ethnographic study. During the course of this work HCS consultants have interacted with user management groups to produce strategic documents. In addition they have acted as a conduit for design improvement and future commercial opportunities within their own organisation. In my role as researcher/manager I have also operated in many different contexts as researcher/observer, interim departmental manager, and participant in the regional pathology network. The influence of the researcher/manager as a sociomaterial boundary object was observed during the course of this research to significantly influence the transfer of organisational routines from Organisation X to Organisation Y and hence contributed to the homogeneity of working practices across organisational boundaries. Within Organisation Y, the identification of sociomaterial boundary objects, passing back and forth between corporate managers, was seen to significantly impact the strategic direction of pathology services from a regional perspective.

9.2.1 Contribution to practice

This research represents a contribution to knowledge within the field of technology studies by addressing the final two secondary research questions:

Do such design intentions subsequently have their effect in practice? If so why? If not why not?

The application of the SociomANTerial model during the course of this long-term, multi-site, ethnographic study led to the identification of three separate morphogenetic cycles. In accordance with the morphogenetic approach the outputs of the preceding cycle formed the input to the next running of the cycle. In doing so the sociomANTerial approach allowed the researcher to fully consider the influence of time during the transition from design to subsequent use and considered the impact of broader social structures such organisational culture.

Following the implementation of LSPA technology the embedded design intentions of the supplier to facilitate 'multi-disciplinary' working were only partly realised in practice within both Organisation X and Y. Although new roles for staff were developed and in-house training programmes were initiated for support staff, these structural changes did not include biomedical scientists both for cultural and financial reasons. Ultimately the primary supplier perceived design intention of reducing overall staff BMS staff numbers did not materialise in either organisation during the course of this research.

From a practical perspective however the SociomANTerial model offered the potential to reveal deep generative mechanisms created by the interplay of the social and the material, without relying on the identification of second order emergents such as increased specimen result turnaround time. For example this research highlighted that a combination of poor specimen labelling at ward level, together with misaligned barcode readers and the physical make-up of transport pucks, required both Organisation X and Organisation Y to re-label 30% of specimens received via the order comm route. This research suggests that a collaborative approach is required between system users, managers and technology designers in order to overcome this significant clinical risk to patients. It is argued during the course of this research that user involvement in the design process will lead to innovative technologies and improved organisational design.

The identification of these material affordances and constraints in practice on a micro scale within the reception area of Organisation Y were also acknowledged to have an impact on a ‘macro’ scale with regard to pathology modernisation.

As a result of the impact of the UK government agenda to modernise pathology services, Organisation Y entered into a second morphogenetic cycle as a result of external pressure primarily aimed at reducing operating costs. At this stage of the research HCS management consultants were observed to directly influence the structural morphogenetic cycle. Operational and workforce data collected in a manner analogous to Zuboff’s (1988) desire to ‘informate rather than automate’ would ultimately form the basis of a document used to influence corporate managers within Organisation Y. As identified earlier in this chapter the production of this document in conjunction with the researcher as interim manager was observed to act as a sociomaterial boundary object passing between corporate managers and system users.

During the third running of the cycle this document inscribed with structural meaning, developed in collaboration with suppliers, managers and service users, would ultimately influence the strategic direction of the department. A collaborative decision was therefore made by the group to pursue internal rationalisation rather than external consolidation of services. This profound decision ultimately contributed to the demise of the N.E Path network.

This collaborative approach to organisational design ultimately appeared to bring about structural morphogenesis, as the majority of staff involved in the process agreed that multi-disciplinary working for support staff and the partial centralisation of cold laboratory services would be an ‘acceptable option’ (Organisation Y, 2012l). The opinion that human/object interactions can act as successful boundary objects, would appear to be supported in practice as groups appeared to be given the space to work together to generate ‘information and work requirements as perceived locally and by groups who wish to cooperate’ (Star, 2010, p.602). In so doing the sociomaterial boundary object displayed a political quality at the pragmatic boundary, where ‘current and novel forms of knowledge can be jointly transformed producing more shared knowledge at the boundary’ (Carlile, 2002, p.453).

This research makes a contribution to practice by suggesting that changes made to the structural cycle alone will only bring about slow and modest change. It is acknowledged however that a collaborative leadership style within a public sector environment can lead to the emergence of ‘primary agents’ into ‘corporate agents’. As corporate agents users of technology are capable of influencing both the structural and cultural morphogenetic cycles. It is argued as a result of this research that only paying attention to the 'ideas, theories, beliefs and values' (Archer, 1995, p179) of staff utilising technology, 'in-practice', will true cultural morphogenesis take place within a public sector environment.

9.2.2 Ethnographic research

This study makes a final contribution to practice by highlighting the importance of ethnographic study in the development of the SociomANTerial model and within the concept of humans as boundary objects. The adoption of technology in practice is considered to require an ethnographic approach in order to fully elucidate the complex interplay between the social and the material. It is suggested that a detailed analysis of users practically engaging with LSPA leads to a deeper understanding of the generative mechanisms involved, including the workarounds developed to overcome material constraints. Long-term ethnographic study has made it possible to trace the material impact of LSPA technology across organisational boundaries. As a consequence multi-site ethnographic research has made it possible to track 'how changes in one organisation affect changes in another' (Leonardi and Barley, 2008, p.167). In doing so this work begins to highlight the impact of materiality on the homogeneity of working practices across organisational boundaries. My own involvement as 'researcher' and 'manager' in the change process is considered to be highly influential. The impact of researcher/manager has been seen to overcome previously identified limitations of multi-site ethnographic studies such as 'depth and breadth of relationship' 'site temporality' (Hannerz, 2003 p.208) and 'time limitations' (Freidberg, 2001, p.263). Conversely however the advantages of long term ethnographic study, as researcher/manager will not be available to the majority of researchers and hence represents a limitation for future research.

9.3 Originality

This longitudinal, multi-site ethnographic study is original in that it represents the first time anyone has attempted to research the effects of the influence of technology on organisations from the design phase through to the subsequent implementation and use in practice.

It is original in explicitly addressing the question of whether designers external to a user organisation intend to influence working practices and organisational structures. In addition it is original in actually identifying how those design intentions were embedded in the technology.

This work is deemed to be original in the fact that the researcher was able to track whether these design intentions actually had their effect in practice within two different organisations. As a result it was possible to identify how those design intentions subsequently influenced the homogeneity of working practice across organisational boundaries.

9.4 Limitations

As noted by Leonardi and Barley (2008) researchers wishing to study the co-evolution of the material and the social face a number of challenges. It would be expected that it would be easier to study technologies that are both 'developed and used within the same organisation' (Leonardi and Barley, 2008, p.167). The inability to relay design deficiencies observed in practice back to the external designers represents a limitation to this research as the on-going cycle of design, use and subsequent re-design could not be completed in an acceptable timeframe.

Secondly this research aimed to bridge the gap between design and use within two NHS organisations. As a researcher/manager I was physically constrained by an inability to investigate both organisations, simultaneously, for the duration of the study. The resultant break in timeline following my transfer from Organisation X to Y represents a limitation and affordance. The inability to follow the selection, implementation and subsequent adoption of technology in both organisations represents an unavoidable limitation to this study. This factor is however countered by the significant affordance of being given access to confidential primary data, which would be unattainable in a 'normal' research setting.

9.5 Future research

This research suggests that bridging the gap between the design, implementation and use of technology, provides a medium with which to explore how sociomaterial networks involving large scale automation, come into being, persist and change over time, within a healthcare environment. Although this has proven to be a very useful strategy to elucidate the influence of designers on user organisations, it is acknowledged that it has proven difficult to complete the design cycle in an acceptable timeframe. This work would then have benefitted from an extension in time frame to adequately inform the primary supplier of the perceived deficiencies of LSPA identified during the course of this research and hence complete an assessment of any redesign features within the two organisations under investigation. Alternatively it may be practically easier to research the introduction of alternate technology at the beginning of the design cycle.

It has been acknowledged during the course of this research that my role as researcher/manager has offered significant affordances with regard to both the access of information, and the ability to observe the sociomaterial interactions 'in practice' over a protracted period of time. The theoretical model generated as a result of this research would therefore benefit from further testing and refinement. Research undertaken by groups or individuals with different perspectives and ideally not involved in the management of the organisations in question would remove any question of methodological bias and provide additional empirical support for the robustness of the model.

A second fundamental limitation of this research was considered to be the type of technology under investigation. It has been acknowledged that investigations into less fixed form technology which can be easily modified by the user or the investigation of technology designed and used within the same organisation may offer significant advantage.

9.6 Final thoughts

This research aimed to develop a theoretical model with which to explore how sociomaterial networks involving large-scale automation, come into being, persist and change over time within a healthcare environment, and to that end the research aims have been met. Adopting a material voluntaristic approach has allowed me to bridge the gap between design and use and explore the intentions of designers on user organisations. An understanding of the material affordances and constraints of technology, together with social factors such as the influence of management consultants and the researcher/manager, have been observed to influence the homogeneity of working practice across organisational boundaries on a 'micro' level. In addition these material affordances and external input from consultants and managers have been observed to influence decision making on a ‘macro’ level resulting in internal organisational centralisation rather than regional consolidation. This research strategy has contributed to our understanding of the complex relationships that exist between the social and the material and has resulted in an operational model which advances our understanding of the impact of large scale technological change on the development of sociomaterial networks over time. In doing, so this research addresses previous concerns that the theoretical concept of ‘sociomateriality’ was of little empirical use.

Chapter 10 Appendices

10.1 Appendix 1 University Ethical approval

Application Ref:

20. **Checklist of documents required** prior to consideration by the Subject Discipline or School (please tick those that have been included). All information that will be presented to human subjects/participants must be included. (Guidance in the preparation of the documents is provided within the University Research Ethics and Governance Handbook and on the School Ethics Blackboard site.)

√	
√	a. Research proposal **(required for all amber and red applications)** and to include background with references to the research literature, objectives and methodology
√	b. Subject/Participant Informed Consent Form
√	c. Subject/Participant Information Sheet
	d. Invitation letter to subjects/participants
√	e. Questionnaires (for studies involving qualitative methods, please refer to the University Research Ethics and Governance Handbook)*
	f. Advertisement materials for human subjects/participants
	g. Environmental impact form
	h. Other information that may assist review

*The questionnaire, or, for studies using qualitative methods, the outline of the proposed questionnaire must be submitted. Where an outline of the proposed questionnaire is submitted by a student applicant, this must be followed later by submission of the full questionnaire. **N.B. For all student applicants, this full questionnaire must be submitted with the Ethics Application Amendment Form (available on the School Blackboard Ethics Website) and signed off by the Student, Supervisor/nominated staff and the Discipline Ethics Representative before the questionnaire is used in the research.**

Section E Signatures for projects assessed to fall into the 'amber' category in Section B.
<u>All approvals must be obtained in the form of a written letter signed by the Subject</u> Discipline Ethics Representative who has approved the application before work may begin.

Researcher
Name: CHRIS SHAW
Signature:
Date: 9/6/10

Principal Supervisor
Name: Dr. G BESSON.
Signature:
Date: 9/6/10

Lay Ethics Representative
Name:
Signature:
Date:

Comments (if any):

7

Application Ref:

Decision:

a. Approved without modification
b. Preliminary approval of student application to undertake a study using qualitative methods, subject to submission and approval of the full questionnaire
c. Further information required before resubmission to the School Ethics Committee (see comments)
d. Rejected (see comments)

Subject Discipline Ethics Representative who has assessed and approved the application on behalf of the School Ethics Committee (A different Subject Discipline Ethics Representative must sign off the form when the Principal Supervisor is also a Subject Discipline Ethics Representative.)

Name: RICHARD. N. RANSON

Signature: R Ranso

Date: 01/09/10

8

10.2 Appendix 2 NHS Ethical cover letter

NHS

National Research Ethics Service

[redacted]

[redacted]

17 June 2010

Mr C Shaw
41 Faraday Court
Durham
DH1 4FG

Dear Mr Shaw

[redacted]

Thank you for seeking the Committee's advice about the above project. You provided the following documents for consideration:

Research proposal

This document has been considered by the Alternate Vice Chair, who has advised that the project does not require ethical review by a NHS Research Ethics Committee.

This letter should not be interpreted as giving a form of ethical approval to the project or any endorsement of the project, but it may be provided to a journal or other body as evidence that ethical approval is not required under NHS research governance arrangements.

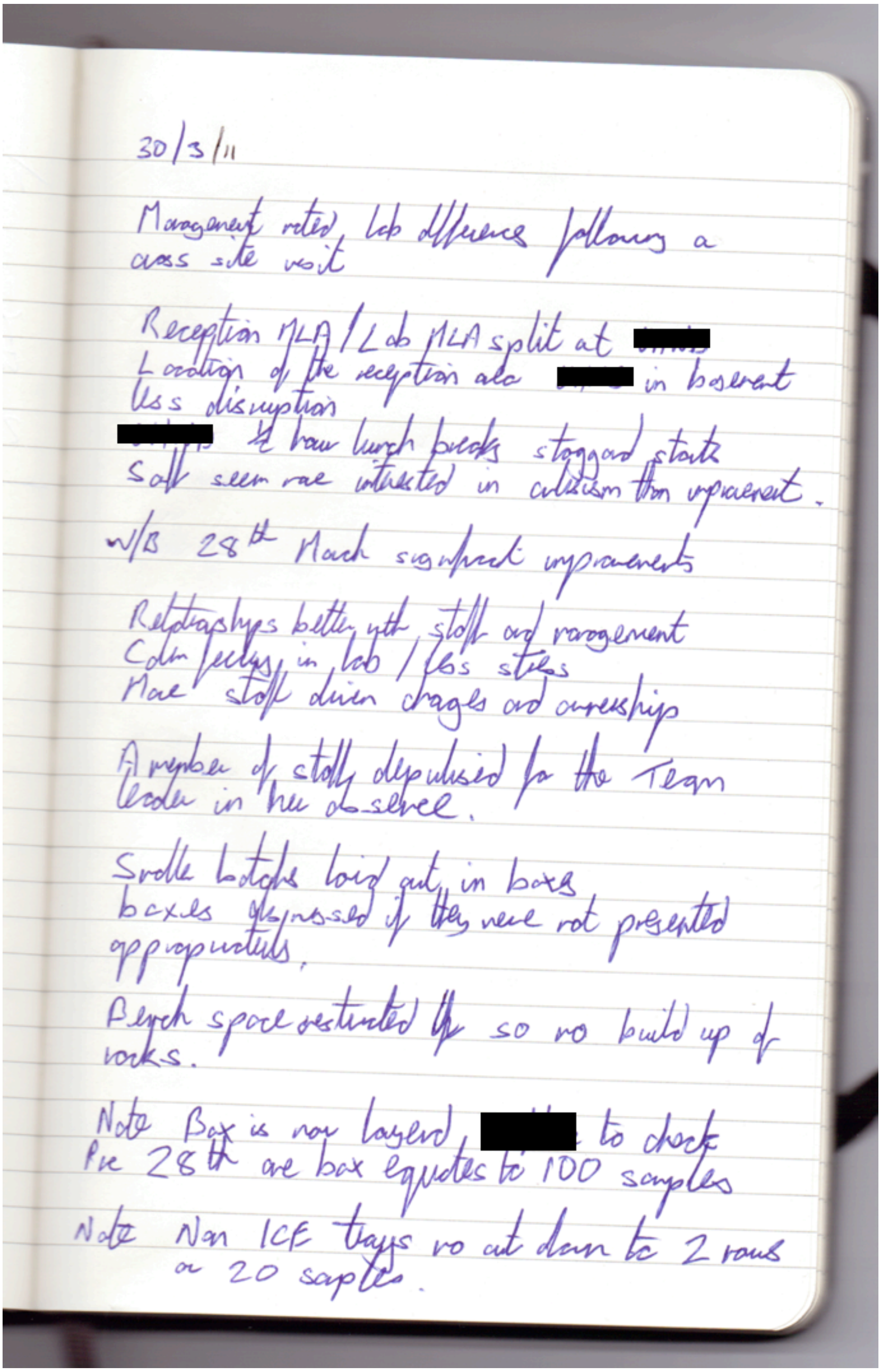
However, if you, your sponsor/funder or any NHS organisation feels that the project should be managed as research and/or that ethical review by a NHS REC is essential, please write setting out your reasons and we will be pleased to consider further.

Yours sincerely

[redacted]

[redacted]

10.3 Appendix 3 Specimen fieldnotes



30/3/11

Management noted, lab difference following a cross site visit

Reception MLA / Lab MLA split at [redacted]
Location of the reception also [redacted] in basement
less disruption
[redacted] to have lunch breaks staggered starts
Staff seem more interested in criticism than improvement.

w/B 28th March significant improvements

Relationships better with staff and management
Calm feeling in lab / less stress
More staff driven changes and ownership

A member of staff deputised for the Team leader in her absence.

Smaller batches laid out in boxes
boxes dismissed if they were not presented appropriately.

Bench space restricted up so no build up of work.

Note Box is now layered, [redacted] to check
Pre 28th one box equates to 100 samples

Note Non ICE trays now cut down to 2 rows or 20 samples.

10.4 Appendix 4 Interview consent form

CS

16th February 2009

Dear Colleague,

As Haematology manager at (Organisation X) I am currently undertaking a Postgraduate Doctorate in Biomedical Science at the University of Northumbria. The project work for this study involves assessing the impact of full laboratory automation (tracking systems) on the structure of pathology both from a human and technological perspective.

In order to gain a regional overview of the issues surrounding such an undertaking I intend to carry out semi structured interviews with all of the NHS pathology managers in the North East of England. I am hoping to use the anonymised data to build up a picture of perceived benefits or otherwise of introducing such a system over time.

As a pathology manager I am therefore inviting you to participate in this study by agreeing to undertake a short interview with myself, which with your permission will be recorded to facilitate transcription. Of course you are free to decline this request without prejudice.

In order to comply with the relevant ethical issues surrounding such an undertaking I must formally state that any information used by myself as part of this study will be handled in the strictest confidence and that the interview transcriptions will be anonymised and therefore cannot be traced back to the originator.

Similarly by signing this document you are confirming that you have fully understood the nature of the study and are giving me formal consent to both undertake the interview and to use the data in the manner described above.

I the undersigned hereby give my consent to be interviewed as part of this study and for that information to be used as described above.

Name...

Date...

Signature...

10.5 Appendix 5 Study Information Sheet

Study Information for Participants

Dear Colleague,

As Lead Biomedical Scientist in Haematology at (Organisation X) I am currently undertaking a Postgraduate Doctorate in Biomedical Science at the University of Northumbria. The project work for this study involves assessing the impact of full laboratory automation (tracking systems) on the structure of pathology both from a human and technological perspective.

In order to gain a regional overview of the issues surrounding such an undertaking I intend to carry out semi structured interviews with all of the NHS pathology managers in the North East of England. I am hoping to use the anonymised data to build up a picture of perceived benefits or otherwise of introducing such a system over time.

As a pathology manager I am therefore inviting you to participate in this study by agreeing to undertake a short interview with myself, which with your permission will be recorded to facilitate transcription. Of course you are free to decline this request without prejudice.

In order to comply with the relevant ethical issues surrounding such an undertaking I must formally state that any information used by myself as part of this study will be handled in the strictest confidence and that the interview transcriptions will be anonymised and therefore cannot be traced back to the originator.

Your assistance in the research is much appreciated.

Yours sincerely
Chris Shaw MSc FIMBS MBA

10.6 Appendix 6 Template analysis of primary supplier interviews

High level codes	**Primary supplier manager**				
	M1	**M2**	**M3**	**M4**	**M5**
Vision					
Efficiencies in operation/Productivity/capacity	*****		**	**	
Efficiencies in labour/reduce labour	***				
Error reduction	****				
Failsafe automation	***				
Predictable turnaround times	***		**		
Improve STAT turnaround times with new software	*	***			
Selling the range of tests/supplying the whole package				*	**
React to pathology networking (integration consolidation)		***			
Revenue generation					***
Reasoning behind automation					
Lack of qualified staff not being replaced	**		*	**	
Aging workforce	*		*	**	
Prediminently female	*				
Closure of medical technologists schools/skill set	*			*	
Changing working practices					
Technology expected to change working practice	**	*	**	**	**
Introduce Multi disciplinary working/integration consolidation	**	******		**	***
Remove human touch/automate reviously manual techniques	***	*	***		
Requirement to optimise laboratory before you automate	**	**	***		
Requirement to improve sample delivery/front end changes/sample flow		**	***		
Automates dangerous/dirty practices			**		
Standardises process			**	****	
Customer requests primary supplier to set up the system				****	***
Effect on staffing structure					
Expected to change staffing structure	***	***	***	**	*
Will reduce your labour force	***	*			***
Skill mix changes from qualified to junior/ non qualified	*	**	**	***	*
Primary supplier want to suggest changes to staffing structure		**	****		
Match staffing structure to front end operation			*		
Reacting to requests by the market to review staffing structure/ideal staffing structure	*	***********	***		
Suggestions made in conjunction to process improvement		**	***		
Head count reduction not observed					***
Free up people to work in other areas	*				***
Technological features which facilitate staff changes					
Central loading point/sample managers/single platform	*	***	***	****	****
Specimen transportation via track (intelligent routing)	*	**			*
On-line centrifugation		*	**		
Automated alliquoting/primary tube sampling	****	*	*		
Integrated middleware	****	**	****	*****	**
Review by exception (autovalidation) User definable rules	*****		***	****	
Password protected rules base				**	
Push button technology/one touch stuff	*		**	**	
Automated reagent volume analysis/software/calibration/QC			****		
Layout of screens				*	
24/7 out of hours support				**	
Constant loading of racks facilitaes predictable result turnaround times	**		**		

High level codes	Primary supplier manager				
	M1	M2	M3	M4	M5
Influences of homogeneity					
IT experts		*			
User group meetings		*			
Supplier consultant fill gap between customer expectation and what can be achieved	**	***	**********	*	*********
HCS team involvement pre installation		**	**		
HCS given focus scripts from the customer base		*			
Implementors slect best practice from other sites and import				***	
Designed around professional lab staff not necissarily the patients				*	
Auotvalidation rules suggested by primary supplier	*				
Prestige/political reasons				**	
Effect of supplier organisation staffing structure					
Move to include more laboratory trained staff in the implementation team					*****
Influences of hetero geneity					
Physical constraints/footprint of system		**	**		
Staff change system during working day				***	
Workload and test remit differences					*
Cultural/historical practices	***	*		**	*****
Internal politics within laboratory	*	*			*
Lack of Trust in the system/fear of losing sight of the sample					**
Resistance to embrace new technology	*				
Implementation staff set system up to user requirements current practice		****		***	
Route samples elseware for send away		**			
Customers don't understand what they don't know		**	**	**	
Lack of communication		*			
Challenge to the power base/control				**	

* Template Connections

10.7 Appendix 7 - Template analysis of N.E. Pathology manager's interviews

	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
Affordances										
Standardise equipment	***									
Centralise services	**	**					**	**	**	*
Financial	***		*	*				*		
Increase capacity	***	*	*	****	*					*
System modification		*	*	****						
Combine analytical platforms				*			*			
Smooth workflow					**					
Reflex tests				*	*					
Continued processing					*					
Efficiency (improve turnaround time)			*			*		**		
Improve quality						**				
Single point of access								**		
Facilitate skill mix changes	***	**	**	**	****	*	**	****	*	
Adapt to declining workforce			*	***	*					
Change practice during the out of hours period		**		****	*	***	**			
Reduce human error					*	**** *				
Reduce departmental barriers						*	*	**		
Improve work-life balance								*		
Motivation								***		
Innovation										
Improve patient care								*		

Constraints	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
Not all equipment can be tracked		*								
Noisy		**								
Physical	*			***	****					
Delay urgent specimens				***						
Increase result turnaround time in haematology			*	*	***				*	
Long term financial commitment									**	***
Cost									*	
Constrains human agency				***		****				
Central reception area		****		**	***	**	*			

Additional high level codes	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
Perceptions developed from site visits		***		**		**	**			
• (t)				*						
• (u)		**								
• (v)						**				
• (w)				*		*				
• (x)							*			
• (y)							*			
• (z)		*								
Relationship development with supplier				**		***				
Influence of lean principles	*	*	*	*	*	*	*		*	*
Lean training by suppliers				*	*					
Influence of supplier implementation staff				**						

Template key:

Managers 1-3 were identified as either in the process of, or considering purchasing a dual track system i.e. two separate systems for biochemistry and haematology.

Managers 4-6 were identified as having already purchased a dual tracking system.

Managers 7-8 were considering (M7) or had already committed (M8) to purchasing a single tracking system.

Managers 9-10 had considered purchasing an automated tracking system but had decided against it for reasons that will be explored in the text.

* Template connections

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